JDuverne_Job_1_of_1

Printed by HPS Server
for
EAST

Printer: cp4_1024_gbfpptr

Date: 04/18/03

Time: 11:44:01

Document Listing

Document	Selected Pages	Page Range	Copies
US006510109	32	1 - 32	1
US006327091	11	1 - 11	1
US006165394	34	1 - 34	1
Total (3)	77	-	-

head support 46. The parts of the conductive members 42 exposed through th through-holes 109, 110 are contact parts with respect to a checking equipme for checking the connection state of the conductive members 42 with the co of the magnetic head 44 and the electric property of the magnetic head 44.

(139) The parts of the pair of conductive members 42 which are exposed outward and constitute the first elastic displacement portions 47 and the second elastic displacement portion 48 are also processed by one of gold pl nickel plating, and solder plating. Thus, these parts are made anticorros

(140) In the above-described example, the present invention is applied to magneto-optical disc recording/reproducing device for recording and reprodu an information signal. However, the present inventions may also be applied a device having only the recording function.

(141) In the above-described example, the present invention is applied to magneto-optical disc recording/reproducing deice using a magneto-optical recording medium as a recording medium. However, the magnetic head accordi to the present invention is not limited to the above-described example and also be applied to a magnetic recording medium such as a magnetic disk or a magnetic tape.

(142) Industrial Applicability

(143) As described above, the magnetic head according to the present invention can efficiently release the heat generated in the magnetic core toward the proximal end side while improving the magnetic field generation efficiency at the distal end portion of the magnetic core, and can also rea a magnetic head for high-speed recording which can achieve a higher transfe rate. If the magnetic head is applied to the magneto-optical disc recordin device, a higher transfer rate of recording data is realized -and high-spee recording is made possible.

CLAIMS:

What is claimed is:

1. A magnetic head comprising: a substantially prism-shaped magnetic co

is smaller than the cross-sectional area of a proximal end portion; and a wound on the outer circumferential surface of the magnetic core portion; wherein the length of one side of the distal end portion is not less than 0 mm and not more than 0.45 mm, and the length of the other side orthogonal t the one side is not less than 0.4 mm and not more than 0.55 mm.

2. The magnetic head as claimed in claim 1, wherein the height of the s is not less than 0.3 mm and not more than a half of the length of the magne core portion.

3. A magnetic head comprising: a core formed substantially in an E-shap a substantially prism-shaped magnetic core portion having a distal end port cut:out to form a step, the magnetic core portion being form so that the cross-sectional area of the distal end portion is smaller than the cross-sectional area of a proximal end portion, and a pair of yokes arrange both sides of the magnetic core portion; and a coil wound on the outer circumferential surface of the magnetic core portion and supplied with a current based on an information signal to be recorded onto a recording medi wherein the length of one side of the distal end portion of the magnetic co

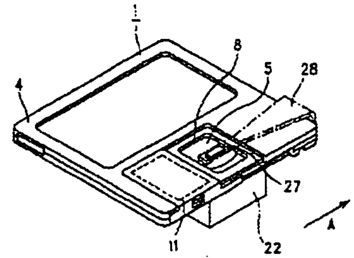


FIG. 7

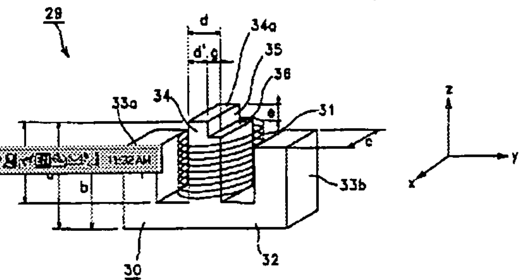


FIG. 8

EAST Browser - L4: (60) block same s... | US 6327091 | Tag: S | 11 | Doc: 11/60 | "Full" 1/11 | Total images 11

File Edit View Tools Window Help

4-211252 August 1992 JP

ART-UNIT: 283

PRIMARY-EXAMINER: Epps; Georgia

ASSISTANT-EXAMINER: Seyrafi; Saeed

ATTY-AGENT-FIRM: Sughrue, Mion, Zinn, Macpeak & Seas, PLLC

ABSTRACT:

There is provided a collimating plate including a transparent support, multiple of light transmitting spheres fixed to the support in partial co therewith and a light blocking area that blocks passage of light through a other than light transmitting areas composed of areas of contact between th support and the spheres and nearby areas. There is also provided a backli system including the collimating plate and a housing that is optically cl by the collimating plate and that includes an inner surface having reflecti properties. They can produce adequately convergent collimated light the intensity of which drops by 50% at angles of no more than .+-. 15 degrees, thereby realizing a liquid-crystal display that can provide a sufficiently contrast ratio over a wide range of viewing angles to be advantageously use medical applications.

7 Claims, 8 Drawing figures

Exemplary Claim Number: 1

Number of Drawing Sheets: 3

BRIEF SUMMARY:

(1) BACKGROUND OF THE INVENTION

(2) This invention relates to the technical field of collimating plates f collimating diffused light and backlight systems utilizing them. More particularly, the invention relates to a collimating plate that can produce adequately convergent collimated light and which hence is particularly suit

(3) The use of liquid-crystal displays (LCDs) as a display for word processors and computers is rapidly increasing today. The use of LCDs as a monitor in ultrasonic, CT and MRI diagnostic apparatus is under review. Conventionally, these medical diagnostic apparatus have primarily used CRTs (cathode-ray tubes) as a monitor.

(4) LCDs have many advantages such as ease in size reduction, small thick and lightweightness. On the other hand, they have poor viewing angle characteristics (narrow viewing angle) in that as the viewing direction or angle changes, the contrast ratio of an image decreases sharply and the gradation also reverses to have the image look differently. As a result, depending on the position of the viewer, the image cannot be viewed correct

(5) In medical applications as described above, diagnosis with monitors i based on the difference in image density, so not only is it required to pr an image of high contrast ratio but at the same time, incorrect recognitio an image can cause wrong diagnosis or inconsistency in the results of diagnoses. Under these circumstances, it is required that high-contrast i be displayed over a wide range of viewing angles. Another problem peculia

US006327091B1

(12) **United States Patent**
Agano

(10) Patent No.: **US 6,327,091 B1**
(45) Date of Patent: **Dec. 4, 2001**

(54) COLLIMATING PLATE AND BACKLIGHT SYSTEM

(75) Inventor: Toshitaka Agano, Kanagawa (JP)

(73) Assignee: Fuji Photo Film Co., Ltd., Kanagawa (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: 09/484,461

(22) Filed: Jan. 18, 2000

(30) Foreign Application Priority Data

Jan. 18, 1999 (JP) 11-009281

(51) Int. Cl.^{7} G02B 27/10; G02B 27/30; G02B 21/60

(52) U.S. Cl. 359/619; 359/452; 359/454; 359/642

(58) Field of Search 359/619, 620, 359/290, 452, 454, 455, 456, 237, 492, 535, 537, 542, 642

(56) References Cited

U.S. PATENT DOCUMENTS

5,428,909		7/1995	Kaszczuk et al.	430/273
5,963,738	*	12/1976	Yates	359/443
5,751,388	*	5/1998	Larson	349/96
5,781,344	*	7/1998	Vance	356/614
5,837,812	*	11/1998	Ge et al.	362/31
6,163,351	*	12/2000	Nakayama	349/61
6,172,814	*	1/2001	Watanabe et al.	359/619
6,254,245	*	7/2001	Uehara	362/31

FOREIGN PATENT DOCUMENTS

2 063 726 A	3/1967	(GB)	E04C/1/42
3-67827	4/1991	(JP)	G03F/7/004
4-211252	8/1992	(JP)	G03F/7/004
5-333202	12/1993	(JP)	G02B/3/02
6-67003	3/1994	(JP)	G02B/3/02
6-230230	8/1994	(JP)	G02B/6/00
7-5326	1/1995	(JP)	G02B/5/02
7-174620	7/1995	(JP)	G02B/5/02
9-104173	4/1997	(JP)	B41M/5/26
9-104174	4/1997	(JP)	B41M/5/26
10-225179	8/1998	(JP)	B41M/5/26

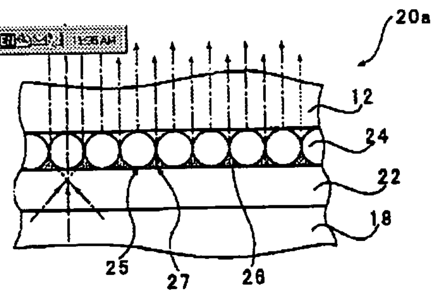
* cited by examiner

Primary Examiner—Georgia Epps
Assistant Examiner—Saeed Seyrafi
(74) *Attorney, Agent, or Firm*—Sughrue, Mion, Zinn, Macpeak & Seas, PLLC

(57) ABSTRACT

There is provided a collimating plate including a transparent support, a multiple of light transmitting spheres fixed to the support in partial contact therewith and a light blocking area that blocks passage of light through areas other than light transmitting areas composed of areas of contact between the support and the spheres and nearby areas. There is also provided a backlight system including the collimating plate and a housing that is optically closed by the collimating plate and that includes an inner surface having reflecting properties. They can produce adequately convergent collimated light the intensity of which drops by 50% at angles of no more than ± 15 degrees, thereby realizing a liquid-crystal display that can provide a sufficiently good contrast ratio over a wide range of viewing angles to be advantageously used in medical applications.

7 Claims, 3 Drawing Sheets



11:35 AM

location accuracy within the allowable range, even in a condition wherein the optical fibers are imbedded in the optical fiber engagement portions so that they cannot expose their crowns, a method of fabricating molds for fabricating optical fiber guide blocks, and a method of fabricating both molds for fabricating optical fiber guide blocks and the optical fiber guide blocks.

(15) According to a first aspect of the present invention, there is provided a grindstone for fabricating a mold for molding by press-molding process at least the optical fiber engagement portions of an optical fiber guide block that has optical fiber engagement portions for the purpose of positioning and aligning optical fibers at a fixed pitch; comprising: two main grinding surfaces that machine formed surfaces that support the sides of the optical fiber; and a shape wherein the angle .theta. subtended by the two tangent lines which touch the two main grinding surfaces in a cross-section perpendicular to the main grinding surfaces constitutes an angle that is equal to or smaller than .theta.c which satisfies the relationship noted below; and the contour of the tip that connects the two main grinding surfaces is contained within an area bounded by the two tangent lines and by a line that is tangent to an imaginary circle and perpendicular to the straight line connecting the intersection of the two tangent lines with the center of the imaginary circle, and that passes between the intersection and the center of the imaginary circle, when the imaginary circle, of radius Rmin as noted below, is inscribed in the area that is in the bight of the two tangent lines.

(1) .theta.c=2 tan.sup.-1 [S.sup.2 -1)/2S]

(16) where:

(17) Rmin=[RO+[RO/sin (.theta./2)]-[YO/tan (.theta./2)]]/[1-[1/sin (74 /2)]],

(18) RO is the optical fiber radius, and

(19) YO is half the pitch length of the optical fiber engagement portion.

(20) According to a second aspect of the present invention, there is provided a grindstone for fabricating a mold for molding by press-molding process at least the optical fiber engagement portion(s) of an optical fiber guide block that has (a) groove-shaped optical fiber engagement portion(s) for the purpose of positioning optical fibers; comprising: two main grinding surfaces that

shape wherein the angle .theta. subtended by the two tangent lines which touch the two main grinding surfaces in a cross-section perpendicular to the main grinding surfaces constitutes an angle that is not greater than .theta.c which satisfies the relationship noted below; and the contour of the tip that connects the two main grinding surfaces is contained within an area bounded by the two tangent lines and by a line that is tangent to an imaginary circle and perpendicular to the straight line connecting the intersection of the two tangent lines with the center of the imaginary circle, and that passes between the intersection and the center of the imaginary circle, when the imaginary circle, of radius Rmin as noted below, is inscribed in the area that is in the bight of the two tangent lines.

(2) .theta.c=2 tan.sup.-1 [S.sup.2 -1)/2S]

(21) where:

(22) Rmin=[RO+[RO/sin (.theta./2)]-[YO/tan (.theta./2)]]/[1-[1/sin (.theta./2)]],

(23) RO is the optical fiber radius, and

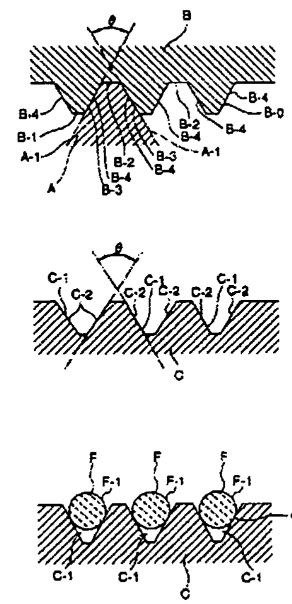


FIG. 3A

FIG. 3B

FIG. 3C

File Edit View Tools Window Help

they cannot expose their crowns, a method of fabricating molds for fabricating optical fiber guide blocks, and a method of fabricating both molds for fabricating optical fiber guide blocks and the optical fiber guide blocks.

(15) According to a first aspect of the present invention, there is provided a grindstone for fabricating a mold for molding by press-molding process at least the optical fiber engagement portions of an optical fiber guide block that has optical fiber engagement portions for the purpose of positioning and aligning optical fibers at a fixed pitch; comprising: two main grinding surfaces that machine formed surfaces that support the sides of the optical fiber; and a shape wherein the angle .theta. subtended by the two tangent lines which touch the two main grinding surfaces in a cross-section perpendicular to the main grinding surfaces constitutes an angle that is equal to or smaller than .theta.c which satisfies the relationship noted below; and the contour of the tip that connects the two main grinding surfaces is contained within an area bounded by the two tangent lines and by a line that is tangent to an imaginary circle and perpendicular to the straight line connecting the intersection of the two tangent lines with the center of the imaginary circle, and that passes between the intersection and the center of the imaginary circle, when the imaginary circle, of radius Rmin as noted below, is inscribed in the area that is in the bight of the two tangent lines.

(1) .theta.c=2 tan.sup.-1 [S.sup.2 -1)/2S]

(16) where:

(17) Rmin=[RO+[RO/sin (.theta./2)]-[YO/tan (.theta./2)]]/[1-[1/sin (74 /2)]],

(18) RO is the optical fiber radius, and

(19) YO is half the pitch length of the optical fiber engagement portion.

(20) According to a second aspect of the present invention, there is provided a grindstone for fabricating a mold for molding by press-molding process at least the optical fiber engagement portion(s) of an optical fiber guide block that has (a) groove-shaped optical fiber engagement portion(s) for the purpose of positioning optical fibers; comprising: two main grinding surfaces that machine formed surfaces that support the sides of the optical fiber; and a shape wherein the angle .theta. subtended by the two tangent lines which touch

grinding surfaces constitutes an angle that is not greater than .theta.c which satisfies the relationship noted below; and the contour of the tip that connects the two main grinding surfaces is contained within an area bounded by the two tangent lines and by a line that is tangent to an imaginary circle and perpendicular to the straight line connecting the intersection of the two tangent lines with the center of the imaginary circle, and that passes between the intersection and the center of the imaginary circle, when the imaginary circle, of radius Rmin as noted below, is inscribed in the area that is in the bight of the two tangent lines.

(2) .theta.c=2 tan.sup.-1 [S.sup.2 -1)/2S]

(21) where:

(22) Rmin=[RO+[RO/sin (.theta./2)]-[YO/tan (.theta./2)]]/[1-[1/sin (.theta./2)]],

(23) RO is the optical fiber radius, and

(24) YO is the interval between the concavities when at least two

FIG. 3A

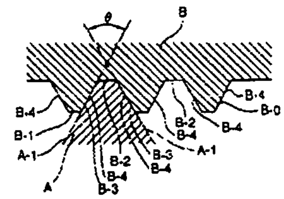


FIG. 3B

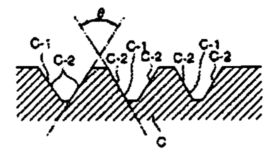
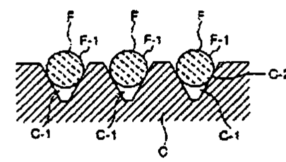


FIG. 3C



(52) YO is half the pitch length of the optical fiber engagement portion.

(53) According to a thirteenth aspect of the present invention, there is provided the mold for fabricating an optical fiber guide block in the twelfth aspect of the present invention, wherein the cross-sectional shapes perpendicular to the longitudinal dimension of a plurality of concavities are the same.

(54) According to a fourteenth aspect of the present invention, there is provided a mold for fabricating an optical fiber guide block, for the purpose of molding, by press-molding process, at least the optical fiber engagement portions of an optical fiber guide block that comprises groove-shaped optical fiber engagement portions for the purpose of positioning optical fibers; comprising: convexities that extend in the longitudinal dimension of the forming surface; and concavities that extend in the longitudinal dimension, arrayed with the convexities sandwiched in between them; wherein: the tangent lines at the points where are formed the portions of the two sloping surfaces that configure the concavities in a cross-section perpendicular to the longitudinal dimension of the concavities, which portions are to support the optical fibers, subtend an angle .theta. that is equal to or smaller than .theta.c which satisfies the relationship noted below; the perpendicular cross-sectional shape of the concavity or concavities is such that the contour thereof is contained within an area bounded by the two tangent lines that touch the sloping surfaces and by a line that is tangent to an imaginary circle and perpendicular to the straight line connecting the intersection of the two tangent lines with the center of the imaginary circle, and that passes between the intersection and the center of the imaginary circle, when the imaginary circle, of radius Rmin as defined below, is inscribed in the area that is in the bight of the two tangent lines; the depth of the concavities is such that the intersection of the two tangent lines is at a position deeper than dmin, as defined below; and one or other of the sloping surfaces that form the concavity or concavities is what forms the surface(s) that support (s) the optical fibers in the optical fiber engagement portion(s).

(10) .theta.c=2 tan.sup.-1 [S.sup.2 -1)/2S]

(55) where:

(56) S=YO/RO,

(.theta./2)]],

(58) dmin=[YO-RO.multidot.tan [(.pi.-.theta.)/4]]/tan (.theta./2),

(59) RO is the optical fiber radius, and

(60) 2YO is the interval between the concavities arrayed so as to sandwich the convexities between them.

(61) According to a fifteenth aspect of the present invention, there is provided the mold for fabricating an optical fiber guide block in the fourteenth aspect of the present invention, wherein the cross-sectional shapes perpendicular to the longitudinal dimension of the concavity or concavities are the same.

(62) According to a sixteenth aspect of the present invention, there is provided the mold for fabricating an optical fiber guide block in the twelfth through the fifteenth aspects of the present invention, having, in place of Rmin, Rmin* which satisfies the relationship noted below.

FIG. 3A

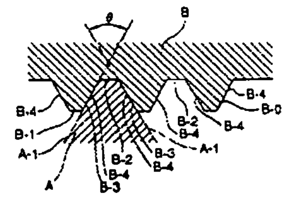


FIG. 3B

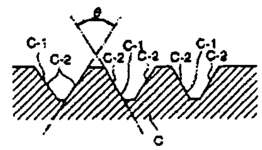
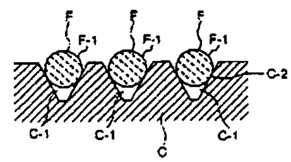


FIG. 3C



EAST Browser - L1: (1947) (385/37).CCLS. | US 6389197 | Tag: S,T | Doc: 585/1947 | "Full" 7/12 (Total images 12)

File Edit View Tools Window Help

Yao; Steve	Diamond Bar	CA	N/A
Wu; Chi	San Marino	CA	N/A

ASSIGNEE INFO
NAME
California In... Technology

Find what: microsphere

APPL-NO:

DATE FILED:

PARENT-CASE:

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims benefit of U.S. Provisional application No. 60/119,435, filed Feb. 10, 1999 and application Ser. No. 60/123,696 filed Mar. 8, 1999.

INT-CL: [07] G02B006/26

US-CL-ISSUED: 385/28, 385/30 , 385/37 , 372/9

US-CL-CURRENT: 385/28, 372/9 , 385/30 , 385/37

FIELD-OF-SEARCH: 385/14; 385/9 ; 385/27-39 ; 385/42-50

REF-CITED:

U.S. PATENT DOCUMENTS

PAT-NO		ISSUE-DATE	PATENTEE-NAME
3915652	N/A	October 1975	Natelson
N/A 5560811	N/A	October 1996	Briggs et al.
N/A 5785926	N/A	July 1998	Seubert et al.
N/A 5840573	N/A	November 1998	Fields
N/A 5926496	N/A	July 1999	Ho et al.
N/A 6122299	N/A	September 2000	DeMars et al.
385/14	N/A		

FOREIGN PATENT DOCUMENTS

FOREIGN-PAT-NO	PUBN-DATE	COUNTRY	US-CL
WO 98/04920	February 1998	WO	
WO 00/44074	July 2000	WO	

OTHER PUBLICATIONS

Ilchenko et al., "Pigtailing the high-Q microsphere cavity: a simple fi... coupler for optical whispering-gallery modes," Optics Letters, vol. 24, No... pp. 723-725, Jun. 1, 1999.

Ilchenko et al., "Microsphere integration in active and passive photoni... devices," Proceedings of SPIE, vol. 3930, pp. 154-162, 2000.

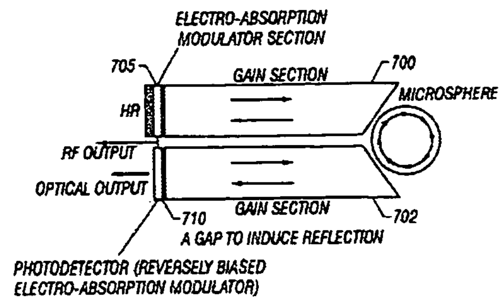


FIG. 7

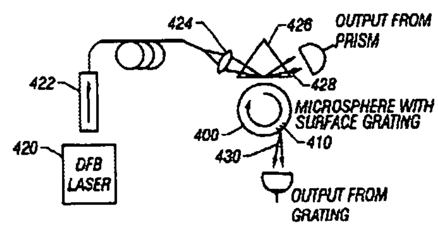


FIG. 8

US006165394A

United States Patent [19]

Shibata et al.

[11] **Patent Number: 6,165,394**

[45] **Date of Patent: Dec. 26, 2000**

[54] **METHOD OF FABRICATING A MOLD FOR FABRICATING OPTICAL FIBER GUIDE BLOCKS**

[75] Inventors: **Gakuei Shibata**; **Teruo Yamashita**, both of Tokyo; **Masahiro Yoshida**, Saitama, all of Japan

[73] Assignee: **Hoya Corporation**, Tokyo, Japan

[21] Appl. No.: **09/469,364**

[22] Filed: **Dec. 22, 1999**

Related U.S. Application Data

[62] Division of application No. 09/042,947, Mar. 17, 1998, Pat. No. 6,032,490.

[30] **Foreign Application Priority Data**

Mar. 17, 1997	[JP]	Japan	9-62796
Jan. 29, 1998	[JP]	Japan	10-17266

[51] **Int. Cl.**^{7} **B29B 11/00**; B24B 7/22

[52] **U.S. Cl.** **264/2.5**; 451/41

[58] **Field of Search** 264/1.1, 2.5; 451/41, 451/231, 233

[56] **References Cited**

U.S. PATENT DOCUMENTS

5,109,460	4/1992	Baek et al. .
5,425,118	6/1995	Sugihara et al. .
5,781,675	7/1998	Tseng et al. .

FOREIGN PATENT DOCUMENTS

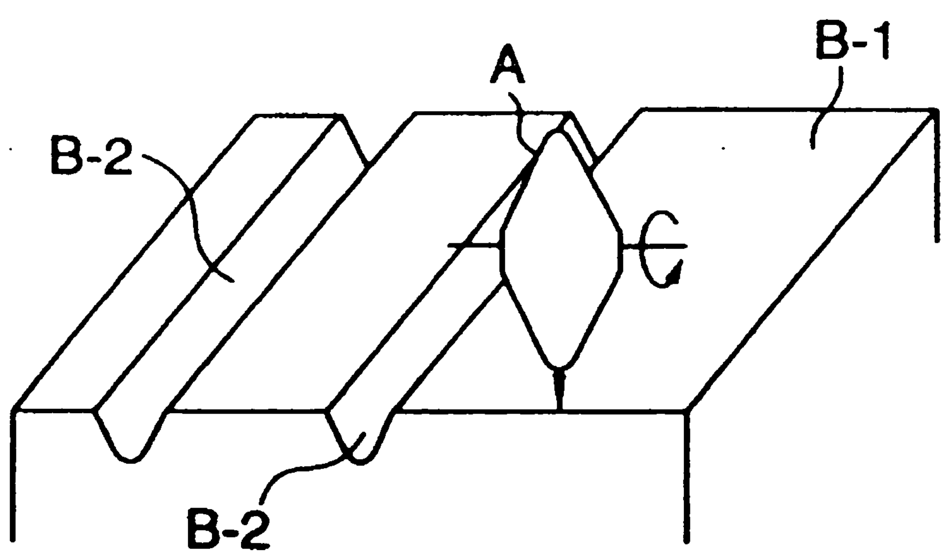
0 410 181	1/1991	European Pat. Off. .
0 420 168	4/1991	European Pat. Off. .
0 667 543	8/1995	European Pat. Off. .
34 28 092	2/1986	Germany .
55-048716	4/1980	Japan .
694945	4/1994	Japan .
6201936	7/1994	Japan .
08197407	8/1996	Japan .
8211244	8/1996	Japan .
90 04196	4/1990	WIPO .

Primary Examiner—Sean Vincent
Attorney, Agent, or Firm—Sughrue, Mion, Zinn, Macpeak & Seas, PLLC

[57] **ABSTRACT**

In a grindstone for fabricating a mold which has optical fiber engagement portions of an optical fiber guide block used for aligning optical fibers, two main grinding surfaces are provided to form the optical fiber engagement portions contacted with the sides of the optical fibers and a tip end portion which is contiguous to the two main grinding surfaces and which has a contour contained within a predetermined area. The predetermined area has a triangle shape which is defined by two tangent lines along the two main grinding surfaces and a preselected line drawn between two points determined on the two main grinding surfaces. The two points are decided in accordance with a predetermined formula.

15 Claims, 18 Drawing Sheets



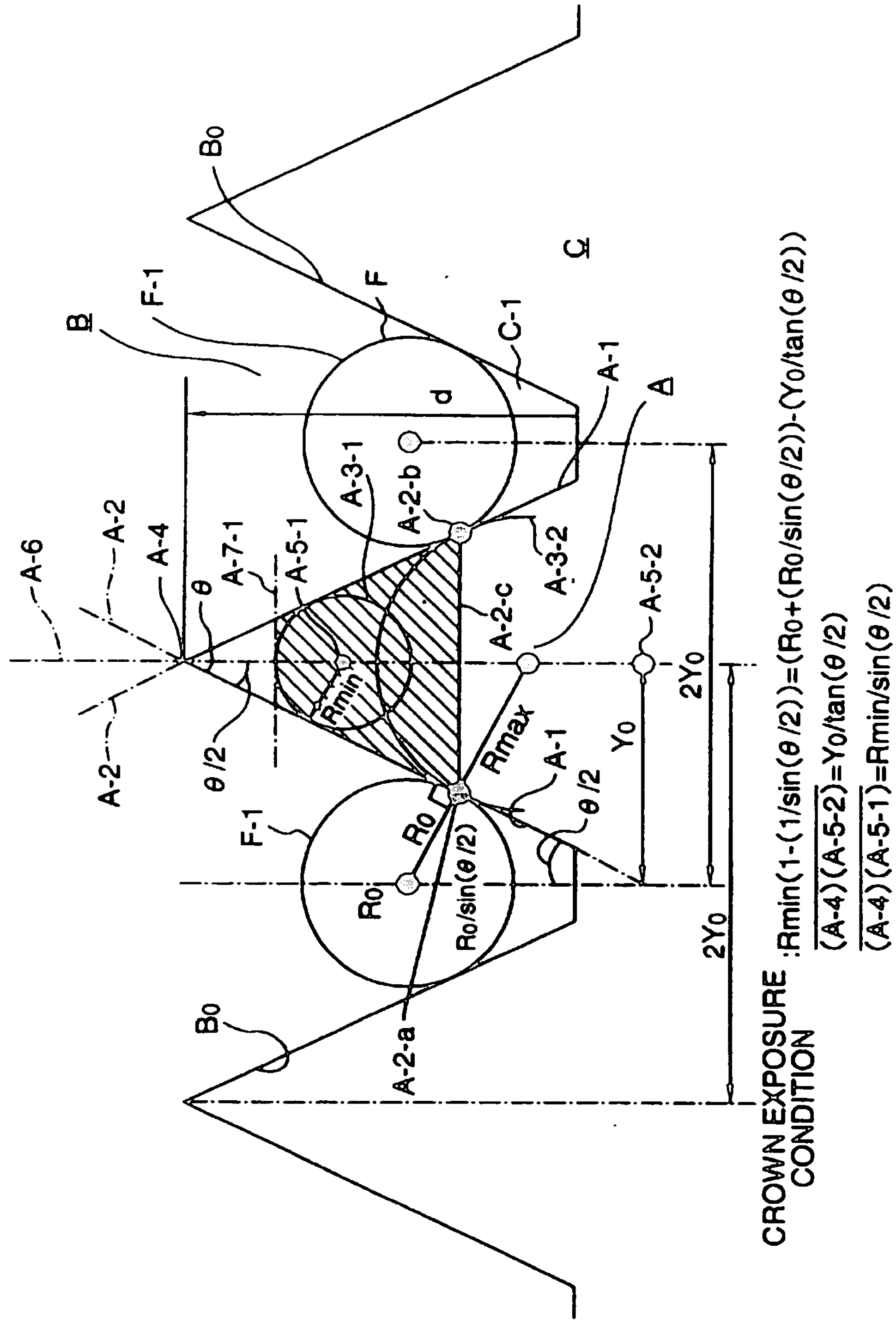

B
F-1
F
Bo
C
C-1
A-1
d
A
A-3-1
A-2-b
A-3-2
A-6
A-2
A-4
θ
A-7-1
A-5-1
A-2-c
A-5-2
Rmin
Rmax
θ/2
Y0
2Y0
Ro
Ro/sin(θ/2)
A-2-a
CROWN EXPOSURE CONDITION
:Rmin(1-(1/sin(θ/2))=(Ro+(Ro/sin(θ/2))-(Yo/tan(θ/2))
(A-4)(A-5-2)=Yo/tan(θ/2)
(A-4)(A-5-1)=Rmin/sin(θ/2)

FIG. 1

FIG. 2A

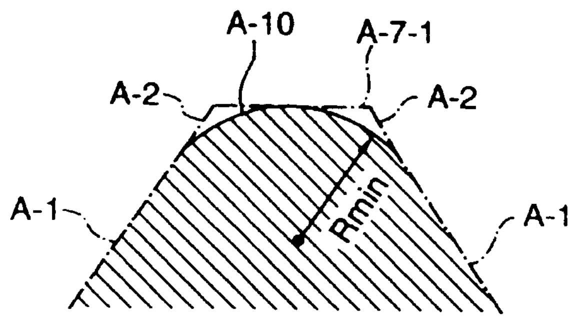


FIG. 2B

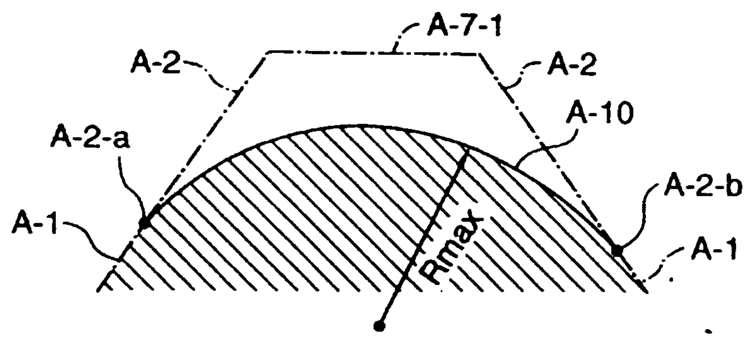


FIG. 2C

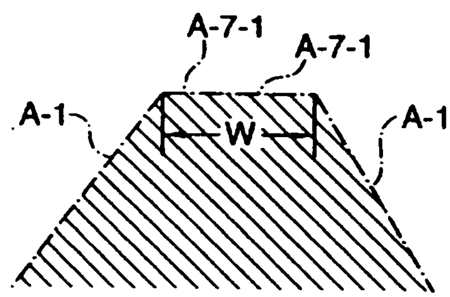


FIG. 2D

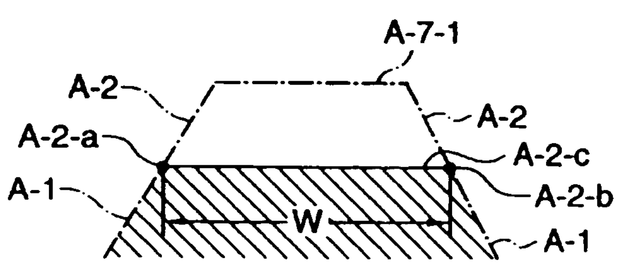


FIG. 3A

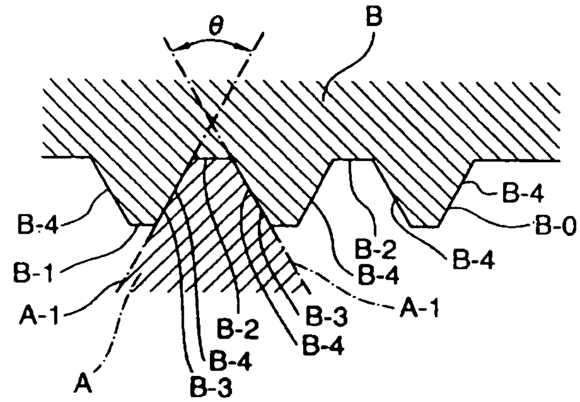


FIG. 3B

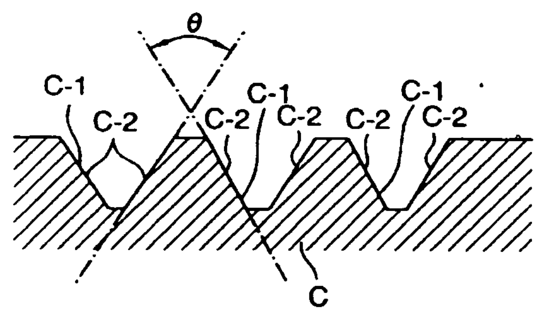
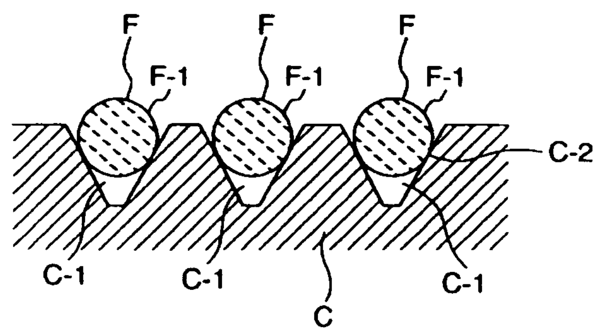


FIG. 3C



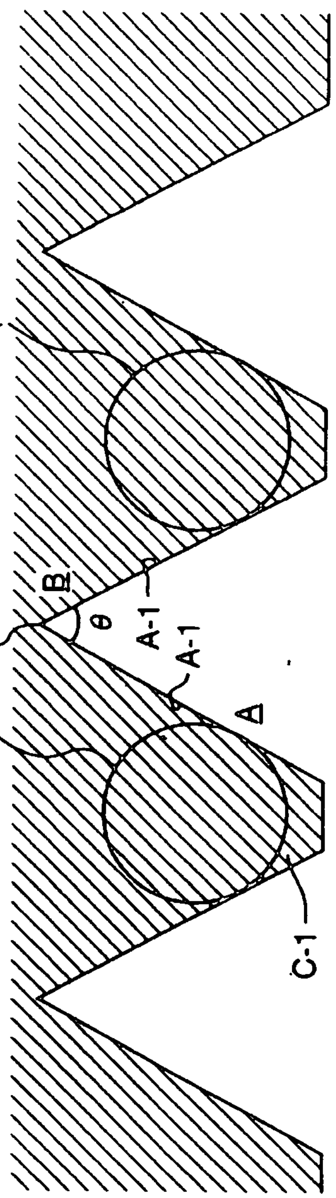


FIG. 4A

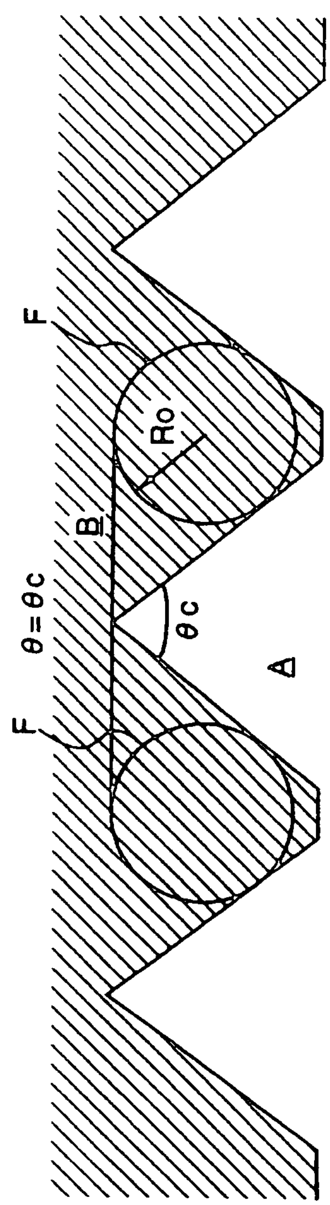


FIG. 4B

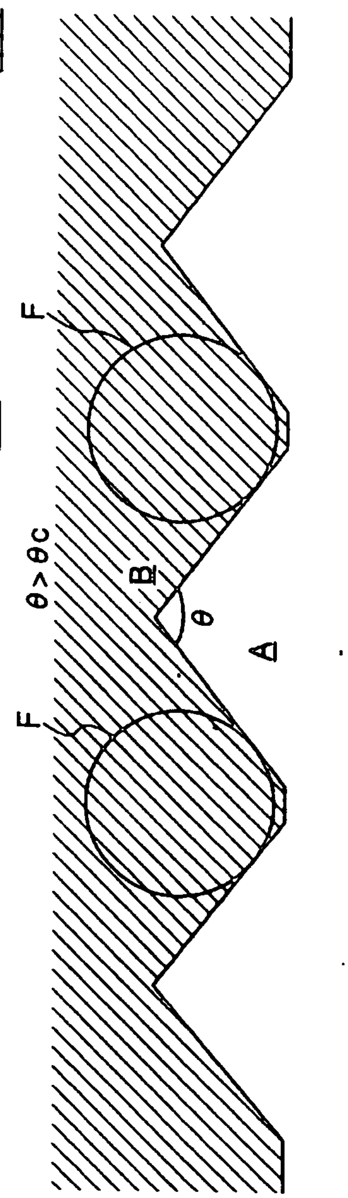


FIG. 4C

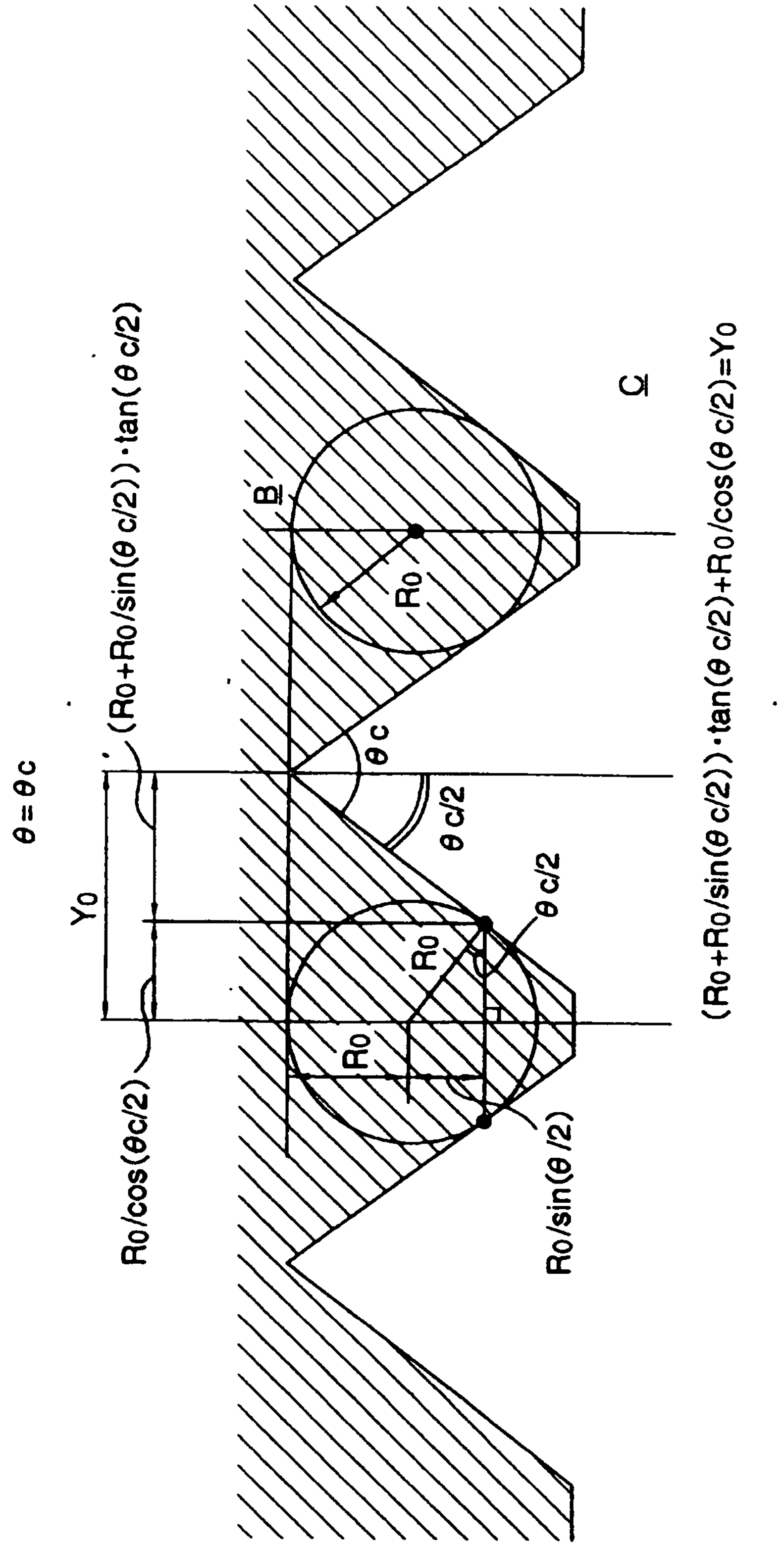

θ = θc
Y0
(R0+R0/sin(θ c/2))·tan(θ c/2)
R0/cos(θc/2)
B
C
R0
θc
θ c/2
θ c/2
R0
R0
R0/sin(θ/2)
(R0+R0/sin(θ c/2))·tan(θ c/2)+R0/cos(θ c/2)=Y0

FIG. 5

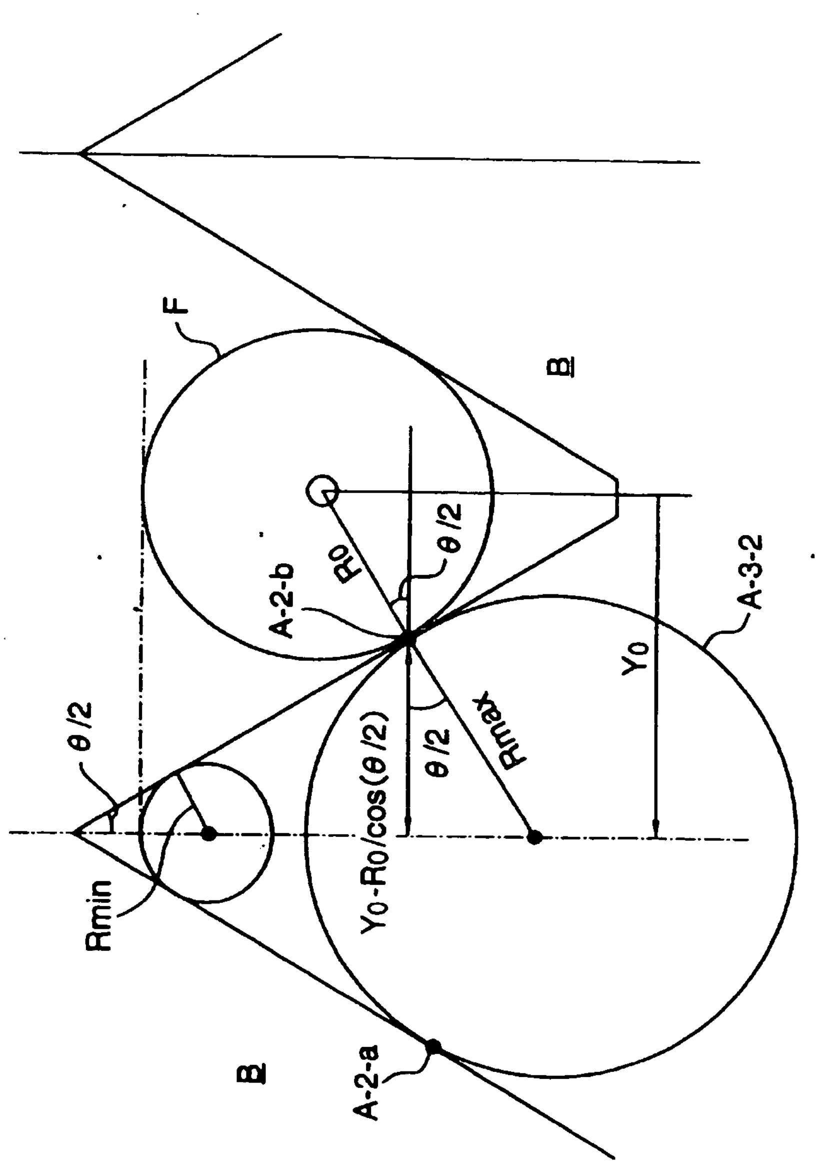


FIG. 6

FIG. 7A

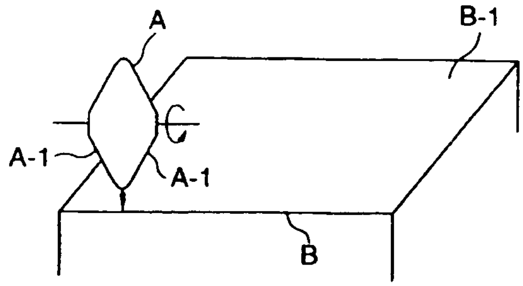


FIG. 7B

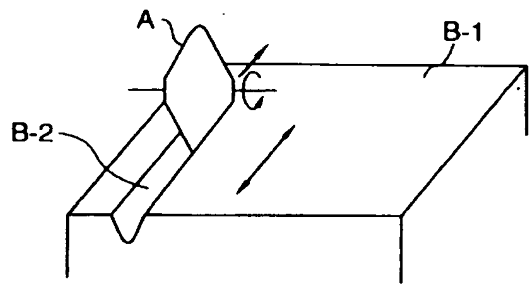


FIG. 7C

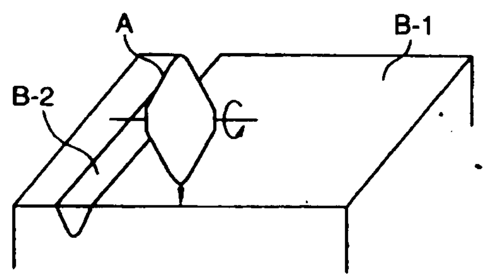


FIG. 7D

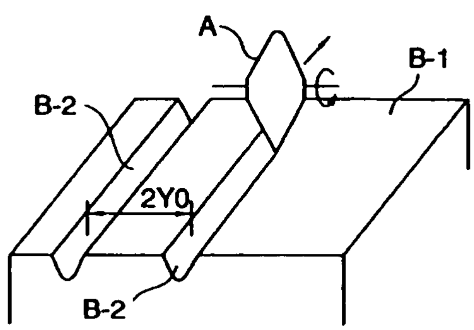


FIG. 7E

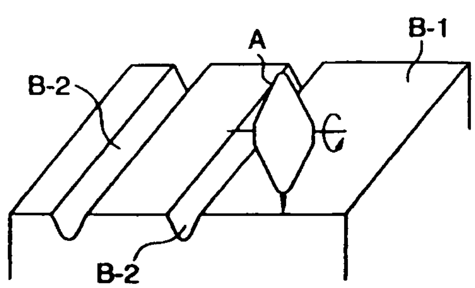


FIG. 8A

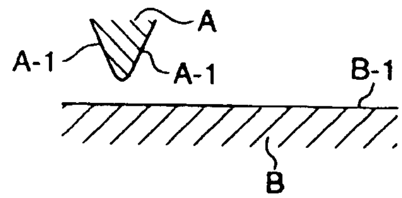


FIG. 8B

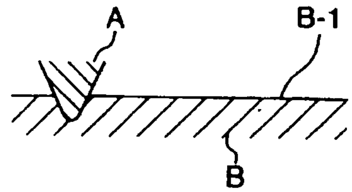


FIG. 8C

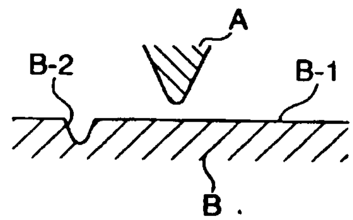


FIG. 8D

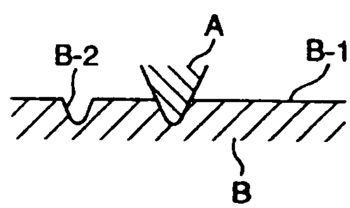
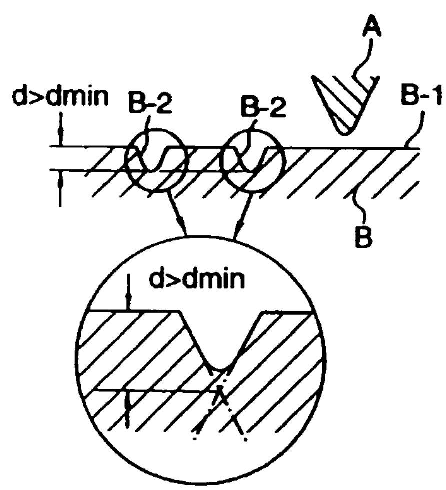


FIG. 8E



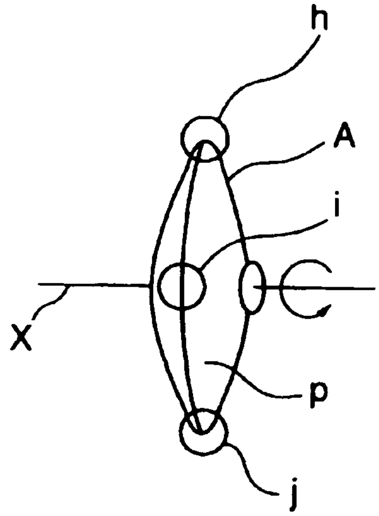


FIG. 9A

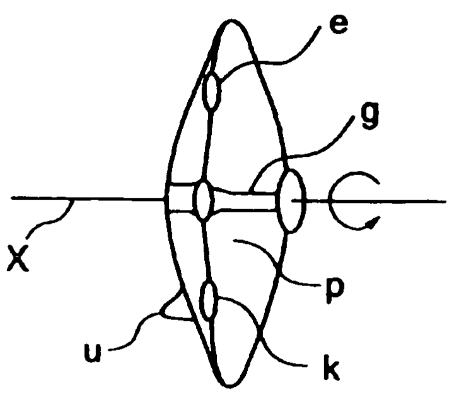
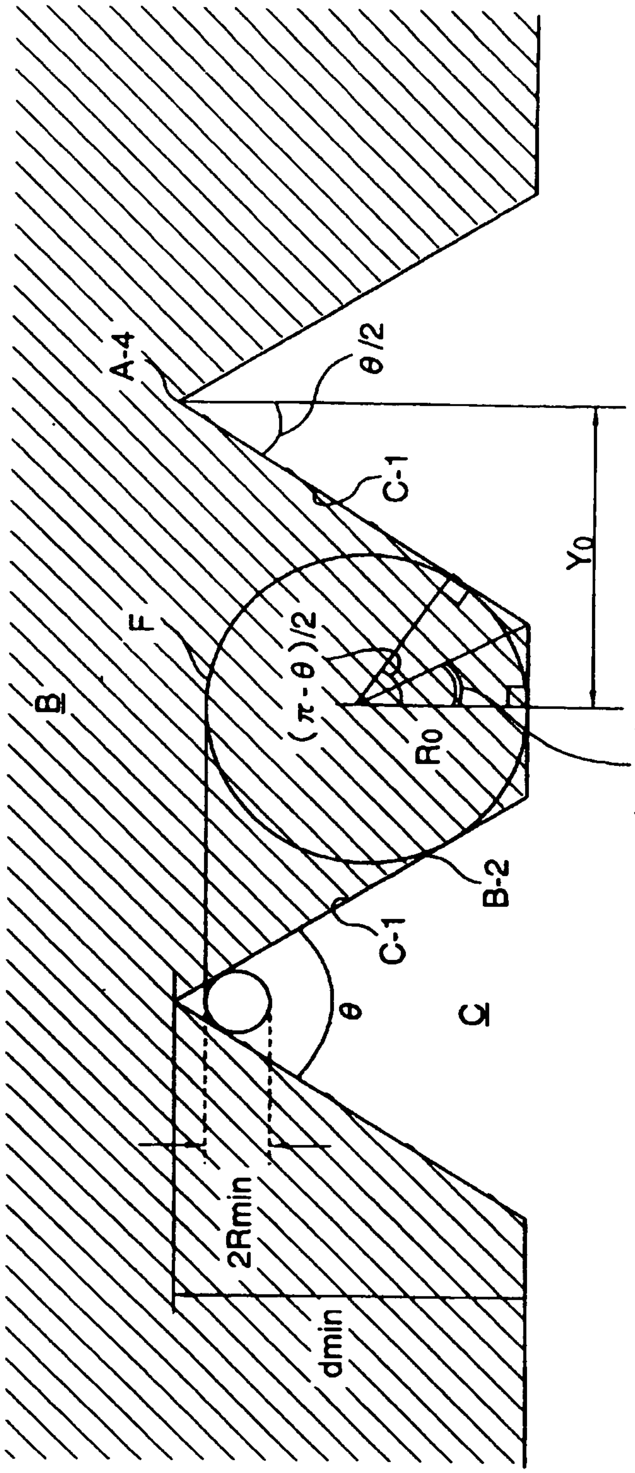


FIG. 9B



TWO-POINT SUPPORT CONDITION: $d_{min} \cdot \tan(\theta/2) = Y_0 - R_0 \cdot \tan((\pi - \theta)/4)$

FIG. 10

FIG. 11A

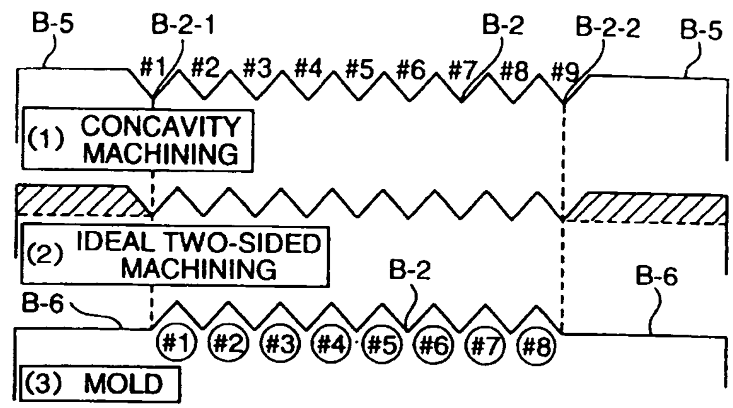


FIG. 11B

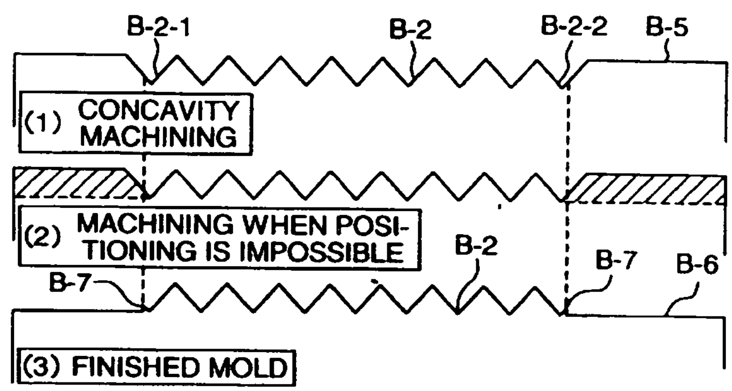
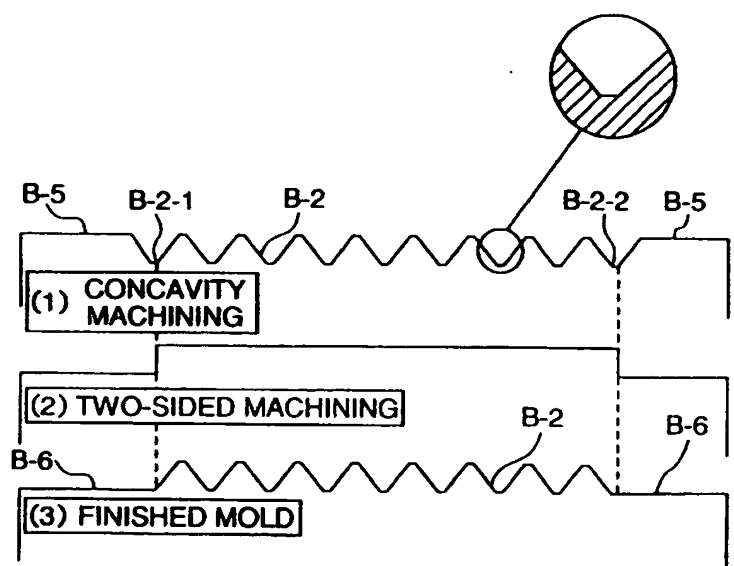


FIG. 11C



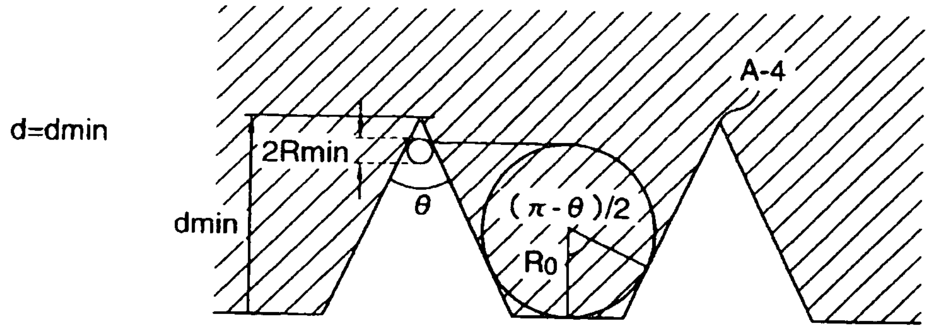


FIG. 12A

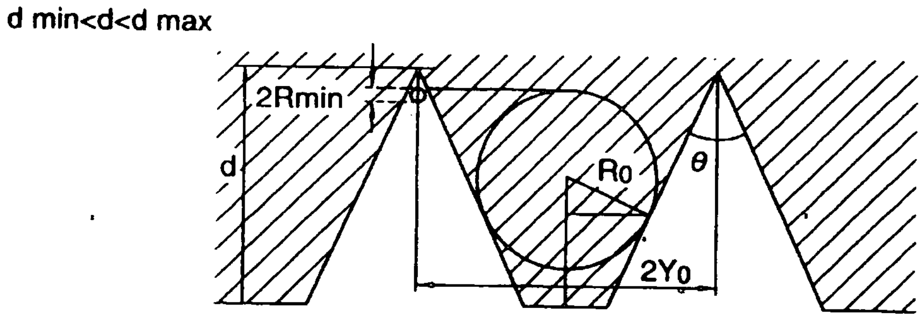


FIG. 12B

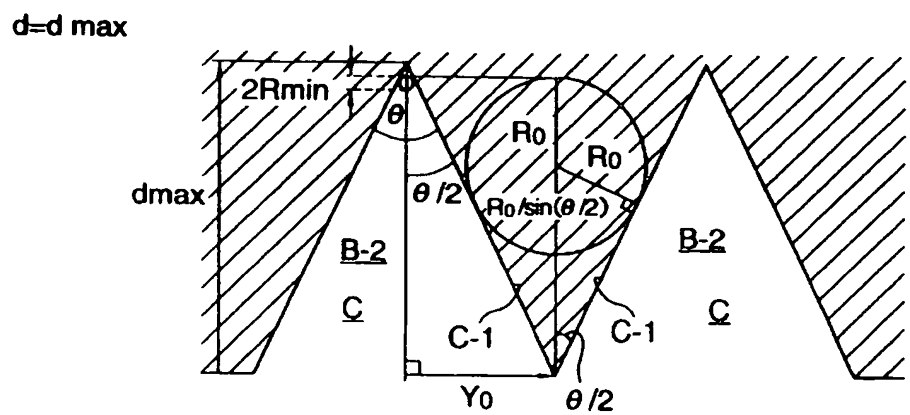


FIG. 12C

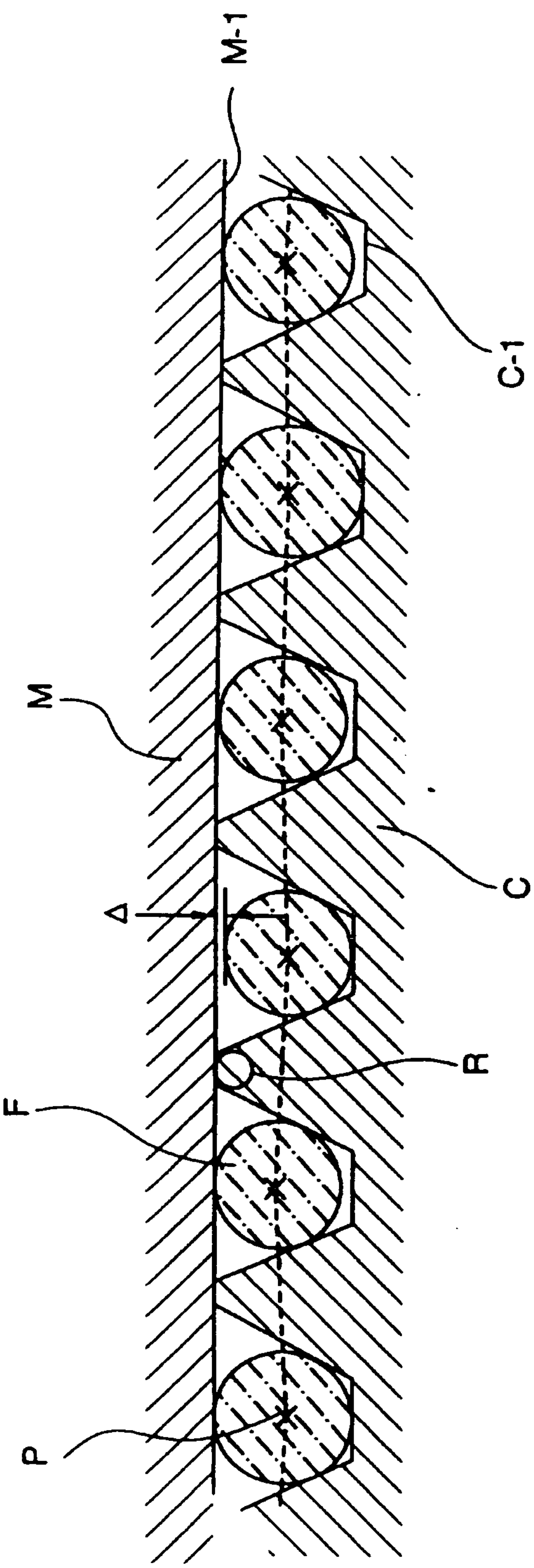


FIG. 13

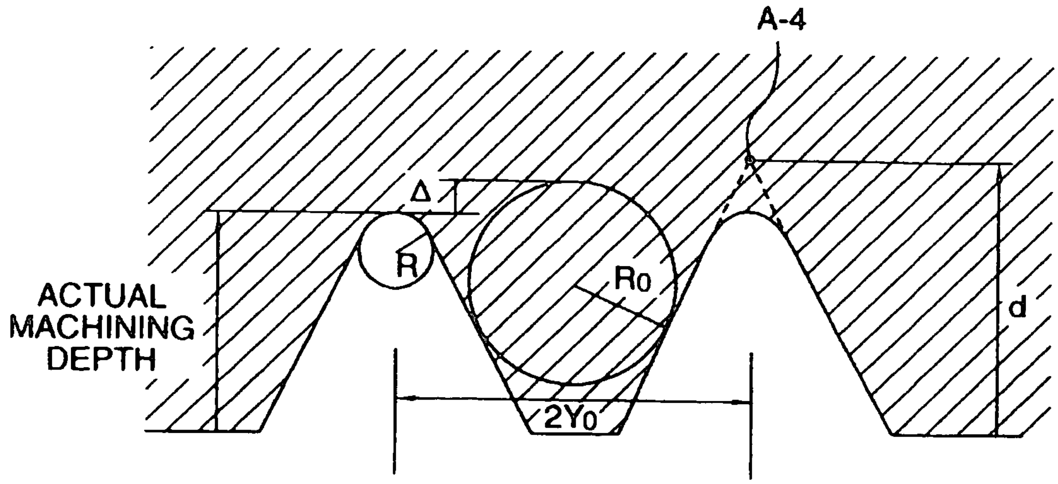


FIG. 14A

R=Rmax

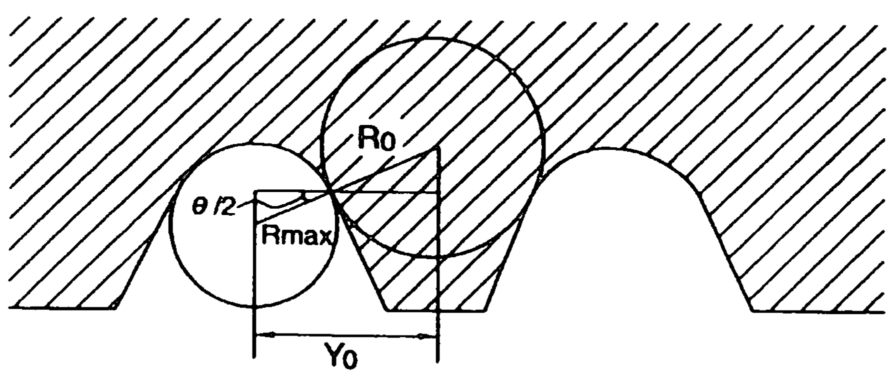


FIG. 14B

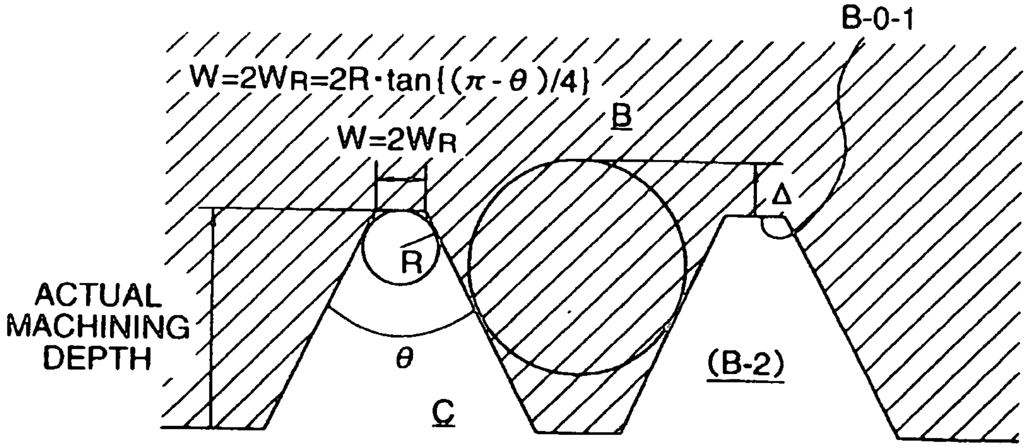


FIG. 15A

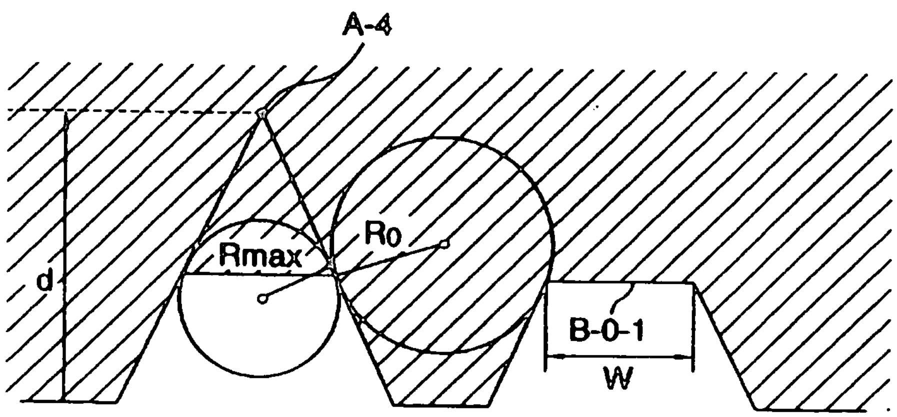


FIG. 15B

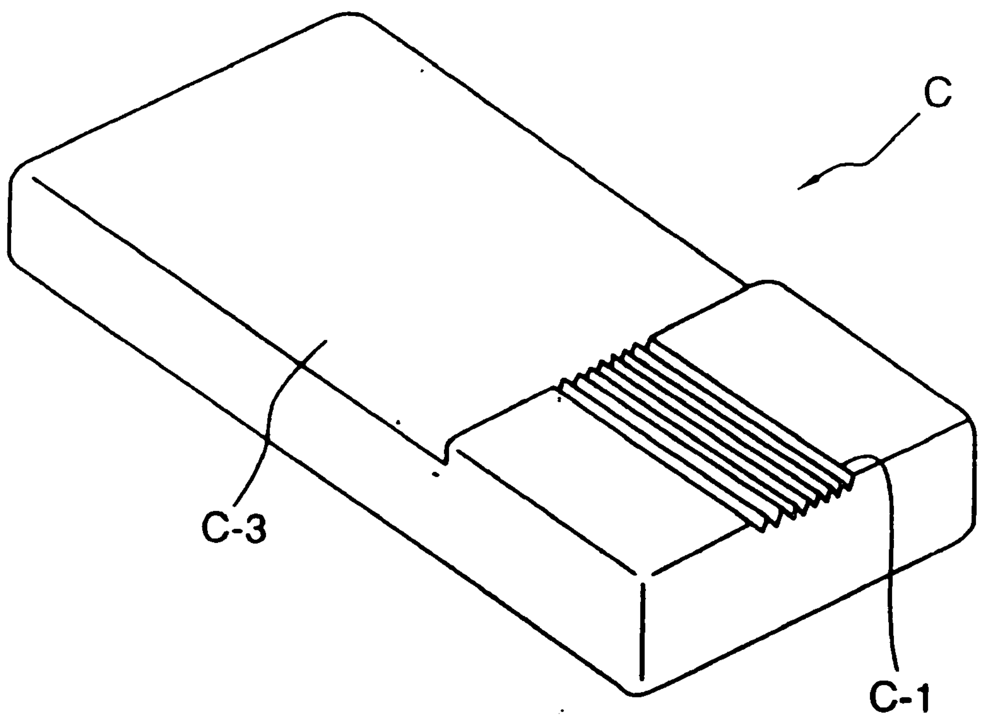


FIG. 16

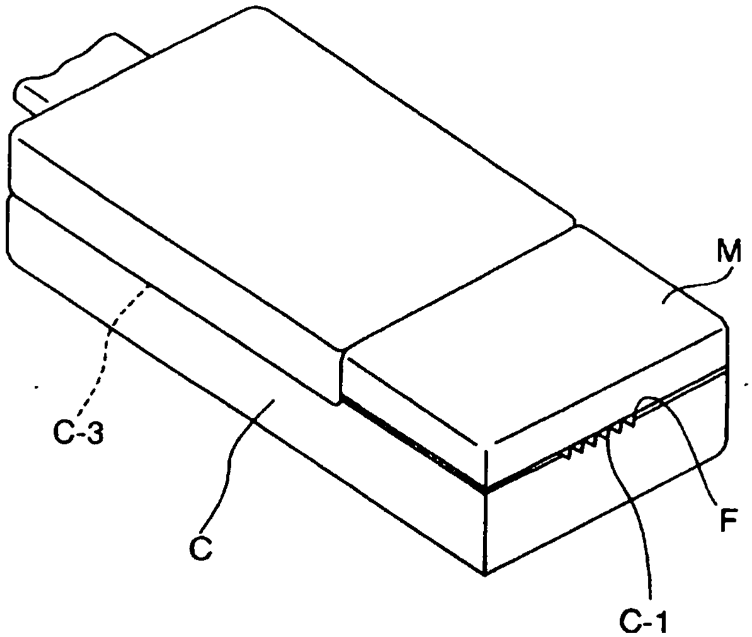


FIG. 17A

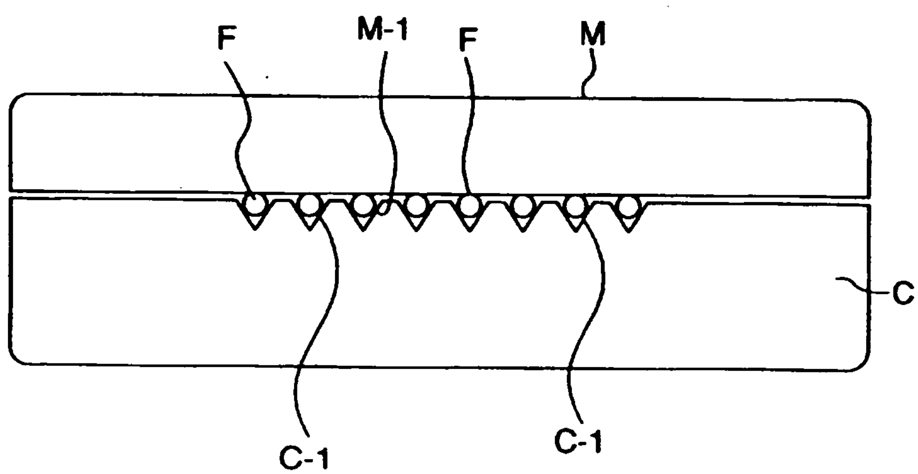


FIG. 17B

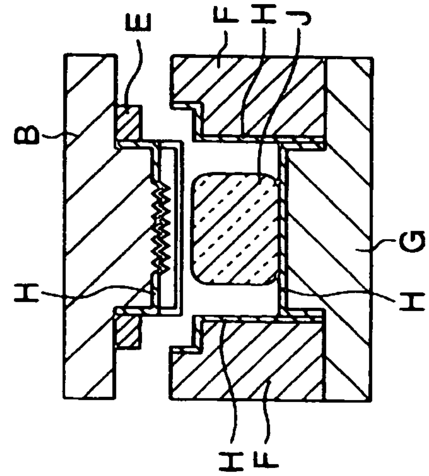


FIG. 18A

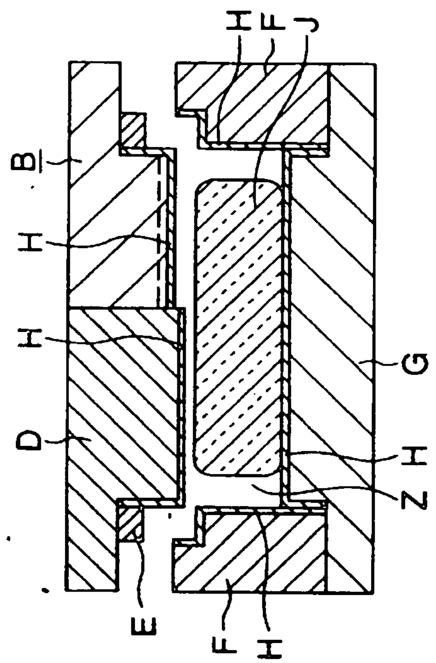


FIG. 18B

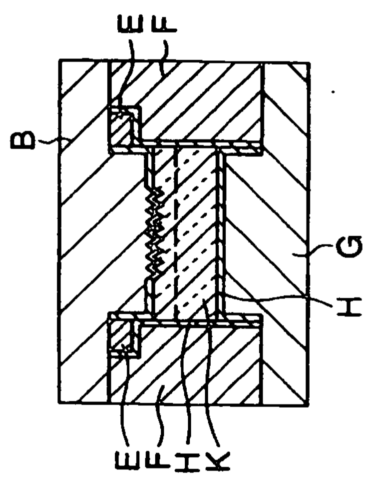


FIG. 18C

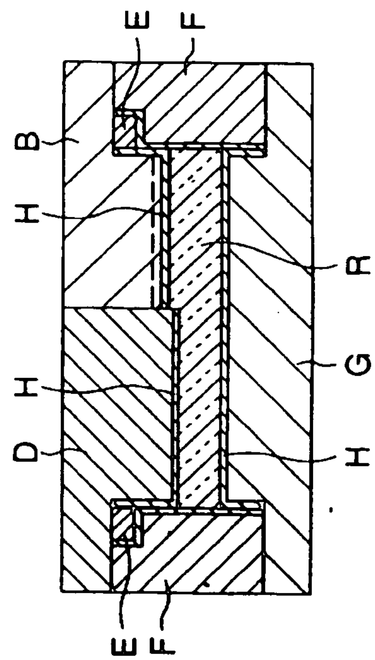


FIG. 18D

METHOD OF FABRICATING A MOLD FOR FABRICATING OPTICAL FIBER GUIDE BLOCKS

This is a divisional of application Ser. No. 09/042,947 filed Mar. 17, 1998 now U.S. Pat. No. 6,032,490, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a grindstone, a method of fabricating molds for fabricating optical fiber guide blocks, molds for fabricating optical fiber guide blocks, and an optical fiber guide block fabrication method, for the purpose of fabricating molds for fabricating optical fiber guide blocks capable of holding and securing the ends of optical fibers in a condition wherein their ends are positioned with high precision and secured.

2. Description of the Related Art

Optical fiber guide blocks which have optical fiber engagement portions are known as securing members for positioning and aligning multifibers at predetermined intervals with high location accuracy. In Japanese Unexamined Patent Publications Nos. Hei 6-201936 [201936/1994] and Hei 8-211244 [211244/1996], for example, optical fiber guide blocks are disclosed which are obtained by forming glass in a hot press.

In Japanese Unexamined Patent Publication No. Hei 6-94945 [94945/1994] is disclosed an optical fiber guide block obtained by press-molding resin.

(1) In the past, the forming parts of optical fiber engagement portions in molds have been formed by dividing the forming surfaces a number of times and grinding a little at a time with grindstones that are very small compared to the size of the work. With this method, in addition to requiring much time for the machining, it is very difficult to make multifiber engagement portion forming parts with high precision, and so that the cross-sectional shape is always the same shape. As a consequence, a shape is varied in configuration when observation is made about the perpendicular cross-sectional shape along the longitudinal dimension of one forming part, or when cross-sectional shapes of different forming parts are compared with each other.

(2) Also, in fabricating optical arrays, the optical fiber ends are engaged and lined up in optical fiber engagement portions in an optical fiber guide block, and pressure blocks are used to press down on and secure the optical fiber ends.

In order to position and secure the optical fiber ends with high location accuracy, it is necessary that the optical fiber sides be supported, at two points by V-shaped optical fiber engagement portions in the optical fiber guide block, in a cross-section seen from a direction perpendicular to the optical axis of the optical fiber ends secured, and at one point by the pressure surface of the pressure block. In the absence of such a three-point support condition, clearances (gaps) will develop between the sides of the optical fiber, on the one hand, and the optical fiber engagement portions or the pressure surface of the pressure block, on the other hand, making it very difficult to implement holding and securing with high location accuracy.

In order to perform optical fiber end securing by the three-point support as described above, when an optical fiber is engaged in an optical fiber engagement portion, not only must the optical fiber engagement portion exhibit a shape wherewith the optical fiber can be stably engaged, but the condition must be such as to permit a portion of the side of the optical fiber to expose its crown, standing away from the optical fiber engagement portion, without being imbedded in the middle of the optical fiber engagement portion. In order to fabricate optical fiber guide blocks having the shape described above by press-molding, a specially shaped mold made to high precision is necessary. Until now, however, no such mold, nor any method for fabricating such mold, has been known.

Furthermore, if the mold can align multifiber ends with a location accuracy within the allowable range, then, on an exceptional basis, a condition wherein optical fiber crown exposure cannot be effected is permissible, but no such mold as this or method for fabricating such mold as this is known either.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention is to provide a grindstone for fabricating molds for optical fiber guide blocks, a fabrication method suitable for fabricating molds for fabricating optical fiber guide blocks for the purpose of fabricating optical fiber guide blocks by press-molding that make it possible to position and secure optical fibers with high location accuracy for the purpose of fabricating molds for fabricating optical fiber guide blocks, and such molds, and also to provide a method for fabricating optical fiber guide blocks wherewith it is possible to position and secure optical fibers with high location accuracy using the molds described in the foregoing.

It is another object of the present invention to provide a grindstone wherewith it is possible to position and align multifiber ends with high location accuracy within the allowable range, even in a condition wherein the optical fibers are imbedded in the optical fiber engagement portions so that they cannot expose their crowns, a method of fabricating molds for fabricating optical fiber guide blocks, and a method of fabricating both molds for fabricating optical fiber guide blocks and the optical fiber guide blocks.

According to a first aspect of the present invention, there is provided a grindstone for fabricating a mold for molding by press-molding process at least the optical fiber engagement portions of an optical fiber guide block that has optical fiber engagement portions for the purpose of positioning and aligning optical fibers at a fixed pitch; comprising: two main grinding surfaces that machine formed surfaces that support the sides of the optical fiber; and a shape wherein the angle θ subtended by the two tangent lines which touch the two main grinding surfaces in a cross-section perpendicular to the main grinding surfaces constitutes an angle that is equal to or smaller than θc which satisfies the relationship noted below; and the contour of the tip that connects the two main grinding surfaces is contained within an area bounded by the two tangent lines and by a line that is tangent to an imaginary circle and perpendicular to the straight line connecting the intersection of the two tangent lines with the center of the imaginary circle, and that passes between the intersection and the center of the imaginary circle, when the imaginary circle, of radius Rmin as noted below, is inscribed in the area that is in the bight of the two tangent lines.

$$\theta c=2\tan^{-1}\{S^2-1)/2S\}$$

where:

Rmin=[RO+{RO/sin (θ/2)}−{YO/tan (θ/2)}]/[1−{1/sin (74 /2)}],

RO is the optical fiber radius, and

YO is half the pitch length of the optical fiber engagement portion.

According to a second aspect of the present invention, there is provided a grindstone for fabricating a mold for molding by press-molding process at least the optical fiber engagement portion(s) of an optical fiber guide block that has (a) groove-shaped optical fiber engagement portion(s) for the purpose of positioning optical fibers; comprising: two main grinding surfaces that machine formed surfaces that support the sides of the optical fiber; and a shape wherein the angle θ subtended by the two tangent lines which touch the two main grinding surfaces in a cross-section perpendicular to the main grinding surfaces constitutes an angle that is not greater than θc which satisfies the relationship noted below; and the contour of the tip that connects the two main grinding surfaces is contained within an area bounded by the two tangent lines and by a line that is tangent to an imaginary circle and perpendicular to the straight line connecting the intersection of the two tangent lines with the center of the imaginary circle, and that passes between the intersection and the center of the imaginary circle, when the imaginary circle, of radius Rmin as noted below, is inscribed in the area that is in the bight of the two tangent lines.

$$\theta c=2\tan^{-1}\{S^2-1)/2S\}$$

where:

- $Rmin=[RO+\{RO/\sin(\theta/2)\}-\{YO/\tan(\theta/2)\}]/[1-\{1/\sin(\theta/2)\}]$,
- RO is the optical fiber radius, and
- YO is the interval between the concavities when at least two groove-shaped concavities are formed by the grindstone in a mold material that is to be the mold, so as to form the optical fiber engagement portion(s) between the concavities.

The first aspect according to the present invention comprises optical fiber engagement portions that position and align optical fibers at a fixed pitch, with the restriction being that the optical fiber engagement portions are plural in number and arranged at equal intervals. The second aspect of the invention, however, comprises groove-shaped optical fiber engagement portions for the purpose of positioning the optical fibers, wherefore the optical fiber engagement portion may be singular in number, and also included are those which are not arranged at equal intervals. When there is a single optical fiber engagement portion, there is no such concept as the pitch of the optical fiber engagement portions. However, even with a mold used where there is a single optical fiber engagement portion, at least two B-2's must be formed in FIG. 8E, so the interval between the two B-2's is defined as 2YO.

According to a third aspect of the present invention, there is provided a grindstone that, in the first and the second aspects of the present invention, has Rmin*, which satisfies the relationship noted below, in place of Rmin.

$$Rmin^*=Rmin-(\phi/5)$$

where:

φ is the optical fiber core diameter.

According to a fourth aspect of the present invention, there is provided a grindstone for fabricating a mold for molding by press-molding process at least the optical fiber engagement portions of an optical fiber guide block that has optical fiber engagement portions for the purpose of positioning and aligning optical fibers at a fixed pitch; comprising: two main grinding surfaces that machine formed surfaces that support the sides of the optical fiber; wherein the angle θ subtended by the two tangent lines in a cross-section perpendicular to the main grinding surfaces constitutes an angle that exceeds θc which satisfies the relationship noted below.

$$\theta c=2\tan^{-1}\{(S^2-1)/2S\}$$

where:

- S=YO/RO,
- RO is the optical fiber radius, and
- YO is half the pitch length of the optical fiber engagement portion.

According to a fifth aspect of the present invention, there is provided a grindstone for fabricating a mold for molding by press-molding process at least the optical fiber engagement portion(s) of an optical fiber guide block that has (a) groove-shaped optical fiber engagement portion(s) for the purpose of positioning optical fibers; comprising: two main grinding surfaces that machine formed surfaces that support the sides of the optical fiber; wherein the angle θ subtended by the two tangent lines in a cross-section perpendicular to the main grinding surfaces constitutes an angle that exceeds θc which satisfies the relationship noted below.

$$\theta c=2\tan^{-1}\{(S^2-1)/2S\}$$

where:

- S=YO/RO,
- RO is the optical fiber radius, and
- YO is the interval between the concavities when at least two groove-shaped concavities are formed by the grindstone in a mold material that is to be the mold, so as to form the optical fiber engagement portion(s) between the concavities.

According to a sixth aspect of the present invention, there is provided a method of fabricating a mold for fabricating an optical fiber guide block; wherein the mold is for the purpose of molding by press-molding process at least the optical fiber engagement portions of the optical fiber guide block, the optical fiber guide block comprising: a plurality of optical fiber engagement portions for the purpose of positioning and aligning optical fibers; comprising: a machining process for using a grindstone to grind a plurality of grooves in a mold material which extend in the longitudinal dimension thereof; wherein the interval between the grooves is made the forming part for the optical fiber engagement portions; and the contour of that portion of the forming part which forms the portions that are to support at least the optical fibers forms a portion of the contour shape of the grindstone.

If this method is employed, by performing grinding-machining so that a portion of the contour shape of the grindstone is formed in the shape of that portion of the cross-section of the optical fiber engagement portion forming parts that are to support the optical fiber, it is possible to fabricate molds, with high productivity, so that the cross-sectional shapes of the multifiber engagement portion forming parts are the same. In other words, it is possible, using a single grindstone, to form grooves of the same shape in the mold material, based on the standard shape of the grindstone, and thereby to machine the parts that form the optical fiber engagement portions. As a consequence, it is

possible to form multiple portions having the same shape to a high precision, and to do this in an elegant manner.

According to a seventh aspect of the present invention, there is provided a method of fabricating a mold for fabricating an optical fiber guide block, for the purpose of molding by press-molding process at least the optical fiber engagement portions of the optical fiber guide block; the optical fiber guide block comprising: (an) optical fiber engagement portion(s) for the purpose of positioning and aligning optical fibers at a fixed pitch; wherein the grindstone of one of the aspects of the present inventions cited above, namely the first through the fifth invention, is used; and concavities extending in a prescribed direction, of such depth that the intersection between the two tangent lines will be at a position deeper than dmin, as defined below, are formed, by a grinding process, on the flat surface of the mold material, at the pitch noted above, in a direction perpendicular to the prescribed direction noted above, in a number that is the number of the optical fiber engagement portions plus 1.

$$d_{min}=\{YO-RO\cdot\tan\{(\pi-\theta)/4\}\}/\tan(\theta/2)$$

According to an eighth aspect of the present invention, there is provided a method of fabricating a mold for fabricating an optical fiber guide block, for the purpose of molding by press-molding process at least the optical fiber engagement portions of said optical fiber guide block; the optical fiber guide block comprising: (a) groove-shaped optical fiber engagement portion(s) for the purpose of positioning optical fibers; wherein the grindstone of one of the aspects of the present invention cited above, namely the first through the fifth aspects of the present invention, is used; and a plurality of concavities extending in a prescribed direction, of such depth that the intersection between the two tangent lines will be at a position deeper than dmin, as defined below, are formed, by a grinding process, on the flat surface of the mold material, in a direction perpendicular to the prescribed direction noted above, and such that the interval between at least two of these concavities becomes YO.

$$d_{min}=\{YO-RO\cdot\tan\{(\pi-\theta)/4\}\}/\tan(\theta/2)$$

According to a ninth aspect of the present invention, there is provided a method of fabricating a mold for fabricating an optical fiber guide block, wherein in the seventh or eighth aspects of the present invention, concavities are machined at a depth such that the intersection between the two tangent lines becomes a position that is shallower than dmax, as defined below.

$$d_{max}=YO/\tan(\theta/2)$$

According to a tenth aspect of the present invention, there is provided a method of fabricating a mold for fabricating an optical fiber guide block, comprising: a process for machining such that, after grinding-machining the concavities of the seventh, eighth, or ninth aspect of the present invention, outside of the two grooves positioned outermost among the grooves, the portions which connect to the bottoms of at least those two grooves are in the same plane as the bottoms of those two grooves.

According to an eleventh aspect of the present invention, there is provided a mold for fabricating an optical fiber guide block that has been fabricated by one of the methods cited in the sixth through the tenth aspects of the present invention.

According to a twelfth aspect of the present invention, there is provided a mold for fabricating an optical fiber guide block, for the purpose of molding, by press-molding process, at least the optical fiber engagement portions of an optical fiber guide block comprising optical fiber engagement portions for the purpose of positioning and aligning optical fibers at a fixed pitch; comprising: a plurality of concavities that extend in one direction in the forming surface; wherein: the tangent lines at the points where the portions that are to support the optical fiber at the two sloping surfaces which configure the concavities, in a cross-section that is perpendicular to the longitudinal dimension of the concavities, subtend an angle θ that is equal to or smaller than θc which satisfies the relationship noted below; the perpendicular cross-sectional shape of the concavities is such that the contour thereof is contained within an area bounded by the two tangent lines that touch the sloping surfaces and by a line that is tangent to an imaginary circle and perpendicular to the straight line connecting the intersection of the two tangent lines with the center of the imaginary circle, and that passes between the intersection and the center of the imaginary circle, when the imaginary circle, of radius Rmin as defined below, is inscribed in the area that is in the bight of the two tangent lines; the depth of the concavities is such that the intersection of the two tangent lines is at a position deeper than dmin, as defined below; and the forming surfaces between the concavities are what form the optical fiber engagement portions.

$$\theta c=2\tan^{-1}\{(S^2-1)/2S\}$$

where:

$S=YO/RO$,

$R_{min}=[RO+\{RO/\sin(\theta/2)\}-\{YO/\tan(\theta/2)\}]/[1-\{1/\sin(\theta/2)\}]$,

$d_{min}=[YO-RO\cdot\tan\{(\pi-\theta)/4\}]/\tan(\theta/2)$,

RO is the optical fiber radius, and

YO is half the pitch length of the optical fiber engagement portion.

According to a thirteenth aspect of the present invention, there is provided the mold for fabricating an optical fiber guide block in the twelfth aspect of the present invention, wherein the cross-sectional shapes perpendicular to the longitudinal dimension of a plurality of concavities are the same.

According to a fourteenth aspect of the present invention, there is provided a mold for fabricating an optical fiber guide block, for the purpose of molding, by press-molding process, at least the optical fiber engagement portions of an optical fiber guide block that comprises groove-shaped optical fiber engagement portions for the purpose of positioning optical fibers; comprising: convexities that extend in the longitudinal dimension of the forming surface; and concavities that extend in the longitudinal dimension, arrayed with the convexities sandwiched in between them; wherein: the tangent lines at the points where are formed the portions of the two sloping surfaces that configure the concavities in a cross-section perpendicular to the longitudinal dimension of the concavities, which portions are to support the optical fibers, subtend an angle θ that is equal to or smaller than θc which satisfies the relationship noted below; the perpendicular cross-sectional shape of the concavity or concavities is such that the contour thereof is contained within an area bounded by the two tangent lines that touch the sloping surfaces and by a line that is tangent to an imaginary circle and perpendicular to the straight line

connecting the intersection of the two tangent lines with the center of the imaginary circle, and that passes between the intersection and the center of the imaginary circle, when the imaginary circle, of radius Rmin as defined below, is inscribed in the area that is in the bight of the two tangent lines; the depth of the concavities is such that the intersection of the two tangent lines is at a position deeper than dmin, as defined below; and one or other of the sloping surfaces that form the concavity or concavities is what forms the surface(s) that support(s) the optical fibers in the optical fiber engagement portion(s).

$$\theta c=2\tan^{-1}\{S^2-1)/2S\}$$

where:

S=YO/RO,

Rmin=[RO+{RO/sin (θ/2)}−{YO/tan (θ/2)}]/[1−{1/sin (θ/2)}],

dmin=[YO−RO·tan {(π−θ)/4}]/tan (θ/2),

RO is the optical fiber radius, and

2YO is the interval between the concavities arrayed so as to sandwich the convexities between them.

According to a fifteenth aspect of the present invention, there is provided the mold for fabricating an optical fiber guide block in the fourteenth aspect of the present invention, wherein the cross-sectional shapes perpendicular to the longitudinal dimension of the concavity or concavities are the same.

According to a sixteenth aspect of the present invention, there is provided the mold for fabricating an optical fiber guide block in the twelfth through the fifteenth aspects of the present invention, having, in place of Rmin, Rmin* which satisfies the relationship noted below.

$$Rmin^{*}=Rmin-(\phi/5)$$

where:

φ is the optical fiber core diameter.

According to a seventeenth aspect of the present invention, there is provided a mold for fabricating an optical fiber guide block, for the purpose of molding, by press-molding process, at least the optical fiber engagement portions of an optical fiber guide block comprising optical fiber engagement portions for the purpose of positioning and aligning optical fibers at a fixed pitch; comprising: a plurality of concavities that extend in one direction in the forming surface; wherein: the tangent lines at the points where the portions that are to support the optical fiber at the two sloping surfaces which configure the concavities, in a cross-section that is perpendicular to the longitudinal dimension of the concavities, subtend an angle θ that exceeds θc which satisfies the relationship noted below; the depth of the concavities is such that the intersection of the tangent lines is at a position deeper than dmin, as defined below; and the forming surfaces between the concavities are what forms the optical fiber engagement portions.

$$\theta c=2\tan^{-1}\{S^2-1)/2S\}$$

where:

S=YO/RO,

dmin=[YO−RO·tan {(π−θ)/4}]/tan (θ/2),

RO is the optical fiber radius, and

YO is half the pitch length of the optical fiber engagement portion.

According to an eighteenth aspect of the present invention, there is provided the mold for fabricating an optical fiber guide block in the seventeenth aspect of the present invention, wherein the cross-sectional shapes perpendicular to the longitudinal dimension of a plurality of concavities are the same.

According to a nineteenth aspect of the present invention, there is provided a mold for fabricating an optical fiber guide block, for the purpose of molding, by press-molding process, at least the optical fiber engagement portions of an optical fiber guide block that comprises groove-shaped optical fiber engagement portions for the purpose of positioning and supporting optical fibers; comprising: convexities that extend in the longitudinal dimension of the forming surface; and concavities that extend in the longitudinal dimension, arrayed with the convexities sandwiched in between them; wherein: the tangent lines at the points where are formed the portions of the two sloping surfaces that configure the concavities in a cross-section perpendicular to the longitudinal dimension of the concavities, which portions are to support the optical fibers, subtend an angle θ that exceeds θc which satisfies the relationship noted below; the depth of the concavities is such that the intersection of the tangent lines is at a position deeper than dmin, as defined below; and one or other of the sloping surfaces that form the concavity or concavities is what forms the surface(s) that support(s) the optical fibers in the optical fiber engagement portion(s).

$$\theta c=2\tan^{-1}\{S^2-1)/2S\}$$

where:

S=YO/RO,

dmin=[YO−RO·tan {(π−θ)/4}]/tan (θ/2),

RO is the optical fiber radius, and

2YO is the interval between the concavities arrayed so as to sandwich the convexities between them.

According to a twentieth aspect of the present invention, there is provided the mold for fabricating an optical fiber guide block in the nineteenth aspect of the present invention, wherein the cross-sectional shapes perpendicular to the longitudinal dimension of the concavity or concavities are the same.

According to a twenty-first aspect of the present invention, there is provided the mold for fabricating an optical fiber guide block in the twelfth through the twentieth aspect of the present invention, wherein the shapes of the bottoms of the concavities in a cross-section perpendicular to the longitudinal dimension of the concavities are the same.

According to a twenth-second aspect of the present invention, there is provided the mold for fabricating an optical fiber guide block in the twelfth through the twentieth aspects of the present invention, wherein the bottoms of the concavities are flat.

According to a twenty-third aspect of the present invention, there is provided the mold for fabricating an optical fiber guide block in the twelfth through the twenty-second invention, comprising: a plurality of concavities, wherein: the forming surfaces bounded between the concavities are flat; and the flat surfaces are positioned in the same plane.

According to a twenty-fourth aspect of the present invention, there is provided the mold for fabricating an optical fiber guide block in the twelfth through the twenty-third aspects of the present invention, having a mold release thin film(s), at least on the forming surface.

According to a twenth-fifth aspect of the present invention, there is provided a method of fabricating optical fiber guide blocks wherein: a mold for fabricating an optical fiber guide block in the twelfth through the twenty-fourth aspects of the present inventions is used; and the raw material to be molded is press-molded under heat.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view describing the correlations between the mold, grindstone, optical fiber, and optical fiber guide block indicating the optical fiber crown exposure conditions according to an embodiment of the present invention;

FIGS. 2A through 2D are a set of cross-sectional views describing the tip shape of grindstones according to the embodiment, FIGS. 2A and 2B depicting circular arc shapes, and FIGS. 2C and 2D depicting flat shapes;

FIGS. 3A through 3C are a set of descriptive drawings of a mold, grindstone, and optical fiber guide block according to the embodiment, FIG. 3A being a cross-sectional view of a mold for molding optical fiber engagement portions, FIG. 3B being a view, seen as a cross-section perpendicular to the optical axis of optical fiber, of the vicinity of optical fiber engagement portions in an optical fiber guide block in a condition wherein optical fibers are engaged in the optical fiber engagement portions, and FIG. 3C being a view, seen in the perpendicular cross-section noted above, of a condition wherein optical fibers are engaged and aligned in V-shaped optical fiber engagement portions in an optical fiber guide block C;

FIGS. 4A through 4C are an explanatory diagram that represents the height relationship between the intersection and the optical fiber crowns in optical fiber engagement portions as the value of the angle θ subtended by the tangent lines in the main grinding surfaces of the grindstone according to the embodiment is changed, FIG. 4A being a cross-sectional view for $\theta<\theta c$, FIG. 4B being a cross-sectional view for $\theta=\theta c$, and FIG. 4C being a cross-sectional view for $\theta>\theta c$;

FIG. 5 is a cross-sectional view of the vicinity of concavities in a mold according to the embodiment when $\theta=\theta c$;

FIG. 6 is an explanatory diagram for deriving Rmax according to the embodiment;

FIGS. 7A through 7E are a set of diagonal views depicting machining processes for fabricating a mold from a mold material by grinding with a grindstone according to the embodiment;

FIGS. 8A through 8E are a set of cross-sectional views corresponding to the processes depicted by the diagonal views in FIGS. 7A through 7E;

FIGS. 9A and 9B are general explanatory diagrams of grindstones according to the embodiment;

FIG. 10 is an explanatory diagram for deriving dmin according to the embodiment;

FIGS. 11A through 11C are explanatory diagrams of two-sided machining according to the embodiment, FIG. 11A depicting ideal two-sided machining, FIG. 11B depicting machining wherewith positioning is impossible, and FIG. 11C depicting two-sided machining in a case where the bottoms of the concavities in the mold are flat;

FIGS. 12A through 12C are a set of cross-sectional views of molds according to the embodiment when the depth of the intersection A-4 is changed, FIG. 12A being when d dmin, FIG. 12B when dmin<d<dmax, and FIG. 12C when d=dmax;

FIG. 13 is a cross-sectional view of the vicinity of optical fiber engagement portions according to another embodiment, wherein the expanded range $Rmin^* \leqq R \leqq Rmin$ applies;

FIGS. 14A and 14B are a pair of cross-sectional views of molds corresponding to Embodiment 1, with FIG. 14A diagramming the case where R>Rmin, and FIG. 14B the case where R=Rmax;

FIGS. 15A and 15B are a pair of cross-sectional views of molds corresponding to Embodiment 2, with FIG. 15A diagramming the case where W=2WR, and FIG. 15B the case where W is made maximum;

FIG. 16 is a diagonal view of an optical fiber guide block according to Embodiment 3;

FIGS. 17A and 17B are a set of explanatory diagrams for an optical fiber array according to Embodiment 3, FIG. 17A being a diagonal view, and FIG. 17B being a front elevation; and

FIGS. 18A through 18D are a set of process drawings which describe a method of fabricating an optical fiber guide block with a mold for press-molding according to Embodiment 3, FIG. 18A being a front cross-sectional view of the front of the press, FIG. 18B a side cross-sectional view thereof, FIG. 18C a front cross-sectional view of the middle of the press, and FIG. 18D a side cross-sectional view thereof.

DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention will now be described specifically, using drawings as appropriate. Before that, however, the main parameters of the present invention will be briefly listed.

(1) Rmin is a crown-exposure condition

(2) dmin is a condition for two-point support by an optical fiber engagement portion

(3) when $\theta \leqq \theta c$, the grindstone tip shape becomes a problem

(4) when Rmax is exceeded, θ cannot be guaranteed (when shape of grindstone tip is a circular arc)

(5) when dmax is exceeded, the mold becomes sharply pointed and breakable

(6) $Rmin \leqq R \leqq Rmax$ is to hold true.

In FIG. 3C diagrammed a condition wherein optical fibers F are engaged and aligned in V-shaped optical fiber engagement portions C-1 in an optical fiber guide block C, as viewed in a cross-section that is perpendicular to the optical axis of the optical fiber. In FIG. 3B is depicted the vicinity of the optical fiber engagement portions in an optical fiber guide block in a condition wherein optical fibers are not engaged in the optical fiber engagement portions. And in FIG. 3A is given a cross-section of a mold B for molding the optical fiber engagement portions diagrammed in FIG. 3B. Here the concavities B-2 of the mold B are formed by grinding-machining using a grindstone A. This grindstone A comprises two main grinding surfaces A-1 which machine the forming surfaces B-0 (including points B-4) that form the surfaces that contain the points C-2 which support the optical fiber sides F-1. The main grinding surfaces A-1 grind the two sloping surfaces B-3 which form the concavities B-2 of the mold B in FIG. 3A. In a cross-section (in a plane parallel to the plane of the page) that is perpendicular to the two main grinding surfaces A-1 of the grindstone A, the angle subtended by the two main grinding surfaces A-1 is designated as θ.

FIGS. 4A through 4C diagram the height relationship between the intersection A-4 and the crowns of the optical fibers F in the optical fiber engagement portions C-1 as the angle θ subtended by the main grinding surfaces A-1 is changed. If we define $\theta=\theta c$ as the angle subtended when the crowns of the optical fibers F and the intersection A-4 coincide (FIG. 4B), then, when $\theta<\theta c$, the optical fibers F will be further imbedded than the position of the intersection A-4 (FIG. 4A), and when $\theta>\theta c$, they will emerge (FIG. 4C). The relational formula for the angle θc is given below.

$$\theta c=2\tan^{-1}\{(S^2-1)/2S\}$$

where

S=YO/RO,

RO is the optical fiber radius, and

YO is half the optical fiber engagement portion pitch length.

This formula is readily derived from FIG. 5, which diagrams a cross-section of the vicinity of the concavities in the mold B with $\theta=\theta c$.

When $\theta\leqq\theta c$ (1)

When a grindstone A wherein the angle θ is less than θc, satisfying the relational equation (1) above, is used, it is expedient to posit two tangent lines A-2 which, as depicted in FIG. 1, touch the main grinding surfaces A-1, and together subtend an angle θ in a cross-section perpendicular to the two main grinding surfaces A-1. The two tangent lines A-2 cross at the intersection A-4. Now, in the region between these two tangent lines A-1, a condition is supposed wherein an imaginary circle A-3-1 having radius Rmin, as defined below, is inscribed. Rmin is the minimum radius of curvature for the tip of the grindstone necessary for the optical fiber crown exposure.

$$Rmin=[RO+\{RO/\sin(\theta/2)\}-\{YO/\tan(\theta/2)\}]/[1-\{1/\sin(\theta/2)\}] \quad (2)$$

This formula (2) defines a critical condition for the crown exposure of the optical fibers F. It can be derived from the cross-sectional view of the mold in FIG. 1.

We next suppose a straight line A-6 that connects the intersection A-4 between the two tangent lines A-2 and the center A-5-1 of the imaginary circle A-3-1, and a tangent line A-7-1 of the imaginary circle A-3-1 that is perpendicular to the straight line A-6 and that passes between the intersection A-4 and the center A-5-1 of the imaginary circle A-3-1. The portion where the two main grinding surfaces A-1 connect in the cross-section of the grindstone A perpendicular to the two main grinding surfaces A-1 will be called the tip of the grindstone A, but the grindstone A that is used has a shape that comprises the contour of this tip within the area bounded by the two tangent lines A-2 and the tangent line A-7-1. This is for the purpose of exposing the crowns of the optical fibers F. More specifically, the grindstone A that is used contains the outline of the tip within the region (including the boundaries thereof) bounded, in FIG. 1, by the straight line A-2-c that connects the points A-2-a and A-2-b, the two tangent lines A-2, and the tangent line A-7-1 (the cross-hatched region in FIG. 1). Such grindstones A include those wherein the cross-sectional shape described is such that the cross-section of the tip is a circular arc A-10, as diagrammed in FIGS. 2A and 2B, and wherein it is such that the tip is flat, as at A-11, as diagrammed in FIGS. 2C and 2D.

When the grindstone tip has a cross-sectional shape that is defined by a circular arc, the aforementioned conditions relative to the grindstone tip shape can be expressed in different terms, as follows. A condition is supposed wherein an imaginary circle A-3-2 of radius Rmax, as defined below, is inscribed in the area bounded by the two tangent lines A-2, as diagrammed in FIG. 1. Rmax is the maximum radius of curvature for the grindstone tip that can guarantee θ.

$$Rmax=\{YO-RO\cos(\theta c/2)\}/\cos(\theta c/2) \quad (3)$$

This formula indicates the radius of the circle A-3-2 that touches a circle of radius RO at the tangent line A-2. Its derivation may be understood from FIG. 6 which diagrams a cross-section of the mold.

In order to expose the crowns of the optical fibers F while guaranteeing θ, it is necessary that the radius of curvature of the grindstone tip satisfy the expression $Rmin\leqq R\leqq Rmax$.

A process wherein a grindstone A of such a shape is used to fabricate, by grinding-machining, a mold B, from a mold material, will now be described. FIGS. 7A through 7E provide diagonal views of the machining process. FIGS. 8A through 8E provide corresponding cross-sectional views of the process depicted in the diagonal views. First a concavity B-2 is ground by a grindstone A of the shape noted above, in the flat surface B-1 of a mold material B (FIGS. 7A and 7B). At this time, the depth of the concavity B-2 is made such that the position of the intersection A-4 is a position that is deeper than dmin, defined below, so that the optical fiber sides F-1 will be supported at two points by the optical fiber engagement portions C-1 of the optical fiber guide block C (FIG. 8E). This is to provide two-point support.

$$dmin=[YO-RO\cdot\tan\{(\pi-\theta)/4\}]/\tan(\theta/2) \quad (4)$$

This formula (4) is easily derived from FIG. 10 which represents the case where d=dmin, the condition necessary for the optical fiber F to touch the bottom of the concavity B-2 of the mold B.

The concavities B-2 are formed so that each extends in the longitudinal dimension, as depicted in FIGS. 7B and 7C, and these are formed in a direction that is perpendicular to the longitudinal direction, with a pitch interval 2YO, in a number that is the number of optical fiber engagement portions to be formed plus 1, and such that the depth between the concavities B-2 is constant (FIGS. 7D and 7E). The point of forming these in a number that is the number of optical fiber engagement portions plus 1 will be explained subsequently with reference to FIGS. 11A through 11C.

When $\theta>\theta c$ (2)

When angle θ exceeds θc, as diagrammed in FIG. 4C, the shape of the tip of the grindstone A may be pointed, or described by a circular arc, or flat, or some other shape. That is because then the crown exposure will be guaranteed irrespective of the tip shape. The method of using a grindstone A shaped in this manner to form concavities B-2 in a mold material B-1 is the same as the method described above. However, the intersection A-4 between the tangent lines A-2 that are the two tangent lines of the main grinding surfaces A-1 in a cross-section perpendicular to the two main grinding surfaces A-1 of the grindstone A, as diagrammed in FIG. 1, is also supposed for the range wherein $\theta>\theta c$, and the depth of the concavities B-2 in the mold B is made to be at a deeper position than the intersection A-4.

Irrespective of the angle θ, the cross-sectional shape of the concavities B-2 will reflect the cross-sectional shape of the

grindstone A used for grinding. More specifically, the angle that is subtended by the tangent line of the mold contour at a point B-4 which forms a place C-2 that supports the optical fiber F diagrammed in FIG. 3C, and, similarly, by the tangent line of the mold contour at the neighboring point B-4, equals θ.

The depth of the concavities B-2, moreover, is made such that the intersection A-4 is deeper than dmin, and shallower than dmax, defined below.

$$dmax=YO/\tan(\theta/2) \qquad (5)$$

This formula (5) is easily derived from FIG. 12C which diagrams the case where d=dmax, which is the condition necessary for the flat bottom to disappear from the engagement portions C-1 of the optical fiber guide block C.

By making it so that the intersection A-4 is at a position that is shallower than dmax, some of the surface B-1 will remain between the concavities B-2 because the surface B-1 (surface wherein the concavities are ground) of the mold material depicted in FIGS. 7A through 7E is flat.

When optical fiber engagement portions C-1 are formed in an optical fiber guide block C using such a mold B as this, what is obtained is an optical fiber guide block C wherein the bottoms of the optical fiber engagement portions C-1 are comprised of flat surfaces (FIGS. 3B and 3C).

The grindstones A of the present invention are mainly used as grindstones which are turned, as represented in FIGS. 7A through 7E. In order to machine the desired mold using the grindstone in this manner, it is necessary:

(1) that the grindstone have a turning shaft; and

(2) that either the main grinding surfaces form symmetrical turning surfaces each of which are centered on a turning shaft, or that the shape thereof be such that imaginary symmetrical turning surfaces can be circumscribed about the main grinding surfaces when the axis of symmetry is made to coincide with the turning axis of the grindstone.

Diagramming this yields FIG. 9A. In this figure, at points h, i, and j, etc., about the periphery of the grindstone, in the grindstones A that are set forth in the first through the fifth invention, the main grinding surface p constitutes a symmetrical turning surface, relative to axis X, in the periphery of the grindstone. However, this does not mean that machining cannot be performed unless it is with a grindstone A having symmetrical turning surfaces, as in FIG. 9A. In some cases it will be possible to perform the machining even if, as in FIG. 9B, a concavity e is made in the periphery, or a groove g is made in the main grinding surface p, or a chip k develops. That being so, the grindstones A of the present invention include those having shapes as in FIG. 9B, so long as, taking the main grinding surface p in FIG. 9A as an imaginary symmetrical turning surface, the grindstone A is such that it can circumscribe such imaginary surface.

By the main grinding surface p, moreover, is meant a surface that, of the surfaces of the grindstone A, is primarily used in grinding. There is no problem with having a projection u in a portion not used in grinding, as depicted in FIG. 9B. In such case, the portion with the projection u is rendered so that it is not contained in the main grinding surface p.

Embodiments of the present invention will now be described.

$$Rmin \leq R \leq Rmax \qquad (1)$$

Grinding machining is performed, while turning a grindstone A, perpendicularly to the surface B-1 of a mold material B, as diagrammed in FIGS. 7A through 7E, so that, taking the surface of the mold material as the reference, the depth is made so that the intersection A-4 diagrammed in FIG. 1 is at a position which is deeper than dmin, as previously defined. After forming a concavity B-2 extending in the longitudinal dimension while moving the grindstone A as depicted in the drawing, the relative positions of the grindstone A and the mold material B are shifted in a direction perpendicular to the longitudinal direction by a pitch of 2YO, and grinding is again done with the grindstone A, so that the depth becomes the same as was formed previously, and so that the concavity B-2 formed previously is paralleled. This process is done repeatedly to grind-machine concavities B-2 in a number equal to the number of optical fiber engagement portions which are to be fabricated by press-molding process plus 1.

It is preferable that the mold material B here have the anti-oxidation properties required for use in press-molding glass, that it be non-reactive with glass, and that it exhibit neither morphological nor plastic change in a high-temperature environment. Silicon carbide, tungsten carbide, alumina, zirconia, crystalline glass, silicon, and cermets of titanium carbide and titanium nitride, etc., may be listed as specific materials. As to the grindstone A for grinding these mold materials B, it may be a resin-bonded diamond grindstone or a metal-bonded diamond grindstone or the like. The grinding process noted above may be performed with a dicing machine or other grinding-machining apparatus used for precision machining.

To add some points here to what has already been said about the shape of the grindstone A, circular arc shapes, flat shapes, and parabolic shapes may be mentioned specifically as shapes for the cross-section of the tip thereof. If the shape is that of a circular arc, or flat, then not only will the grindstone fabrication be comparatively easy, but there will be little degradation in the shape of the tip due to wear, as compared to grindstones having a pointed tip, and the grinding-machining of the whole shape can be done stably.

When the angle θ is equal to or smaller than θc, then, as diagrammed in FIGS. 4A through 4C, if the cross-sectional shape of the grindstone tip is not contained within the area described earlier, press-molding process cannot be performed wherewith optical fiber F crown exposure is possible. When, on the other hand, the angle θ is larger than θc, then optical fiber F crown exposure becomes independent of the cross-sectional shape of the tip of the grindstone A that is used. In other words, even if a grindstone having a sharp tip is used, a mold B can be obtained for forming an optical fiber guide block C wherewith crown exposure of the optical fiber F is possible.

The depth to which the concavities B-2 are ground, that is, the depth of the concavities B-2 of the mold B, must be such that the intersection diagrammed in FIG. 1 is at a position which is deeper than dmin defined earlier. When the position of that intersection A-4 is at dmin or shallower than dmin, then, when an optical fiber F is engaged in an optical fiber engagement portion C-1, the optical fiber F will come in contact with the bottom of the optical fiber engagement portion C-1, the optical fiber F will be pushed up from the two support points of the optical fiber engagement portion C-1, and it will cease to be possible to restrain the position of the optical fiber F in the direction in which the optical fibers F are aligned. When the optical fibers F are engaged and aligned in the optical fiber engagement portions C-1 by a mold B that satisfies the conditions noted above, the crown exposure of each optical fiber F is possible, and an optical fiber guide block C is obtained wherein the optical fibers F are stably engaged in the optical fiber engagement portions C-1.

The optical fibers F are engaged and aligned in these optical fiber engagement portions C-1, the side surfaces of the crown-exposed optical fibers are pressed down under the pressing surface of a pressure block, and bonded and secured. In this condition, an optical fiber array is obtained wherein the optical fiber sides are supported at three points, namely at two points by the optical fiber engagement portions, and at one point by the pressing surface of the pressure block, looking at a cross-section perpendicular to the optical axes of the optical fibers. The light input/output end surfaces of this optical fiber array are optically polished and made ready for actual use.

When the cross-section of the grindstone tip is shaped as a circular arc, if the radius of curvature R of the circular arc increases, and the apex of the grindstone tip moves outside of the straight line A-2-c, outside of the region bounded by the tangent lines A-2, the straight line A-7-1, and the straight line A-2-c, as diagrammed in FIG. 1, then the points C-2 (which are points on the optical fiber guide block C that correspond to points A-2-a and A-2-b in FIG. 1) at which are supported the optical fiber sides F-1 in the optical fiber guide block C in FIG. 3A through 3C cease to be positioned on the main grinding surfaces A-1. In other words, the angles subtended by the tangent lines on the cross-sectional contour of the optical fiber engagement portions C-1 at point C-2, and by the tangent lines on the contour of the forming surfaces B-0 in the mold B that forms the points C-2, cease to be the angle θ subtended by the two tangent lines A-2 that touch the main grinding surfaces of the grindstone.

Now, to explain further about the grinding depth of the concavities B-2, it is desirable that the grinding depth, that is, the depth of the concavities B-2, be such that the intersection A-4 in FIG. 1 be at a position that is shallower than dmax, defined earlier. The reason is that, because the surface of the mold material B in which the concavities are ground is flat, when the grinding depth is made as noted above, some of the flat surface B-1 of the mold material B remains as a forming surface sandwiched between the concavities B-2. In such a mold B as this, the spaces between the concavities B-2 are flat and have no edges which are sharp or thin, wherefore there is no danger of the tips of the concavities B-2 in the mold B being chipped, thus making the mold B easy to handle. If, on the other hand, the depth of the concavities is made deeper than dmax, defined earlier, then sharp and thin edges are produced between the concavities which readily chip and easily lead to problems. When press-molding an optical fiber guide block C, such a mold B as this forms flat surfaces at the bottom of the optical fiber engagement portions C-1. In glass press-molding process that forms flat bottoms like this, after the optical fiber engagement portions C-1 are formed, the stresses that are produced in the tips between the concavities of the mold and in the bottoms of the optical fiber engagement portions C-1 are dispersed in a cooling process, which functions to reduce chipping and cracking in the tips between the concavities in the die.

After subjecting the mold material B to the concavity grinding process, the portions B-5 that are outside of the concavities B-2-1 and B-2-2 that are positioned outermost among the plurality of concavities B-2, in FIG. 11A, and that are connected at least with the bottoms of the outermost concavities B-2-1 and B-2-2, are machined so that they are brought into the same plane B-6 as the bottoms of the concavities B-2-1 and B-2-2 ((1) concavity machining→(2) ideal machining→(3) mold). This process is hereinafter called two-sided machining. By this two-sided machining, a mold is obtained having a shape such that the portions on both sides of the mold and the bottom of the concavities B-2 are positioned in the same plane B-6.

In an optical fiber array comprising an optical fiber guide block C that is press-formed by such a mold B as this, a pressure block, and optical fibers, the gap between the bonding surfaces of the optical fiber guide block C and pressure block can be made uniform at every place.

However, in cases where the bottoms of the concavities in the mold B are not flat (when the grindstone tip shape is made sharp), when performing the two-sided machining, if the positions of the centers of the outermost concavity bottoms B-2-1 and B-2-2 and the ends of the portions removed by the two-sided machining are not accurately positioned, an unwanted non-machined portion having the shape of a projection B-7, as diagrammed in FIG. 11B, will be made. When, however, the bottom of the concavities in the mold B are made flat (when the grindstone tip shape is made flat), then, as diagrammed in FIG. 11C, the positioning precision tolerance can be made as large as the width of the flat bottom of the concavity B-2, so there will be no remaining unmachined portion having the shape of the projection B-7 due to a positioning error. The two-sided machining can be performed accurately by using a dicing machine or other precision machining apparatus in doing the grinding.

After shape-machining the mold as described in the foregoing, a mold release thin film(s) is formed, at least on the forming surfaces B-0 of the mold, to facilitate post-formation die separation of the object being press-formed. The mold release thin film(s) may be carbon-based or platinum alloy-based, etc.

Molds such as this are used to press-form the material being formed, at a press-formable temperature. Using such molds as this, for example, a down die is formed integrally by taking such a mold and another mold for forming the pedestal of an optical fiber guide block for holding an optical fiber sheath and securing these in a frame, using trunk dies and an up die, placing the material to be formed in the space bounded by the down die, trunk dies, and up die, and conducting press-molding at a press-formable temperature. Optical fiber engagement portions are thus formed in the glass that is formed, and an optical fiber guide block is obtained.

The molds of the present invention are not limited to examples in which an optical fiber guide block such as noted above is used. Optical component mounting boards and optical component securing hardware, etc., used in precisely positioning light-emitting devices or light-sensing devices, in addition to optical fibers, can be employed in forming the optical fiber engagement portions.

Any glass that is press-formable can be used as the glass to be formed. However, glass having a low coefficient of thermal expansion, a yield point below 600°, and outstanding UV transmissivity is desired. Glasses containing SiO_2, B_2O_3, and ZnO, for example, may be recommended. Any other commercially sold press glass may be used.

The values for YO and RO arrived at by making compensations based on the mean coefficient of thermal expansion between the glass transition temperature and the room temperature of the mold material and the glass that are press-formed during mold fabrication.

$$R\min^{*} \leq R \leq R\max \quad (2)$$

Now, in describing the embodiment set forth in the foregoing, it is presupposed that, unless the three-point support condition is satisfied, the sides of the optical fiber

ends will develop clearance (gaps) between the optical fiber engagement portions or with the pressing surface of the pressure block, making it very difficult to effect holding and securing with high location accuracy. In actuality, however, it has been found that, even in a condition wherein the optical fibers are embedded inside the optical fiber engagement portions so that crown exposure can no longer be effected, if the range of the radius of curvature R of the grindstone A is expanded as noted below, light connection losses can be kept within allowable limits when an optical fiber array is used in a condition wherein crown exposure can no longer be effected.

When $\theta \leqq \theta c$ (a)

$$Rmin^{*}=Rmin-(\phi/5) \quad (6)$$

In the range where $Rmin<R\leqq Rmax$, when optical fibers are engaged and positioned in optical fiber engagement portions in a crown-exposed condition, and the optical fibers are pressed down with a pressure block, the optical axes of the optical fibers are aligned on a straight line in a cross-section perpendicular to the optical axes.

In the expanded range $Rmin^{*}\leqq R\leqq Rmin$, the amount of optical fiber crown exposure Δ will be $\Delta\leqq 0$. In this condition, when the optical fiber engagement portions C-1 are covered with a pressure block M, as diagrammed in FIG. 13, each of the plurality of optical fibers F will be secured in one of the positions where it is restrained within a range bounded by the pressing surface M-1 of the pressure block M and the optical fiber engagement portion C-1. Because the crown-exposure amount Δ is $\Delta\leqq 0$, however, the optical axes P of the optical fibers F will not be aligned in a straight line in a cross-section perpendicular to the optical axes P. By making $R\geqq Rmin^{*}$, however, even if $\Delta\leqq 0$, the amounts by which the optical axes P of the optical fibers F are shifted away from the straight line will become smaller. This amount of shift is relative to the depth dimension of the optical fiber engagement portions C-1, but the amount of shift in the positions of the optical axes P of the optical fibers F relative to the direction of optical fiber alignment will also become smaller.

When $R<Rmin^{*}$, the amount of shift in the optical axes P of the optical fibers F will become larger, as will the optical connection loss when this optical fiber array is used. Moreover, when single mode fiber (having a core diameter $\phi=10$ μm and an outer diameter $2RO=125$ μm) is used for these optical fibers, it is possible to keep the optical connection loss between optical fiber arrays, or between an optical fiber array and another component (such as when light waveguides having a core diameter of ϕ are configured in an array) within 0.2 dB (a specification deemed necessary in the fields of optical communications and measurement, etc.) by making $Rmin^{**}\leqq R\leqq Rmax$ (where $Rmin^{**}=Rmin-(\phi/10)$.

When $\theta>\theta c$ (b)

If θ is within this range, then optical fiber crown exposure is possible irrespective of the cross-sectional shape of the grindstone tip (i.e. the cross-sectional shape of the bottom of the concavities in the mold), and there is no need to consider a minimum value for R in order to make crown exposure possible. Accordingly, nothing is changed from before the expansion.

The mold fabrication method described thus far, wherein a mold material is machined by grinding with a grindstone having a cross-sectional shape perpendicular to two main grinding surfaces that approximates the cross-sectional shape perpendicular to the optical axes of the optical fibers when those optical fibers are engaged and arrayed in optical fiber engagement portions in an optical fiber guide block, forming concavities in prescribed positions and in a prescribed direction, affords advantages in that high-precision molds having shapes faithful to their design can be fabricated with good reproducibility and good productivity.

The present invention is not limited to the fabrication of optical fiber guide blocks in which optical fiber engagement portions are arrayed at a constant pitch. The invention may also be applied to an optical fiber guide block having but one optical fiber engagement portion. For example, two concavities such as are diagrammed in FIG. 8E may be formed at an interval of 2YO, and, if two-sided machining is performed, as diagrammed in FIGS. 11A through 11C, a mold can be obtained for fabricating an optical fiber guide block having but one optical fiber engagement portion. Depending on the case, if a mold release thin film(s) is formed on the forming surfaces, and a material to be forming such as glass is press-formed, an optical fiber guide block having but one optical fiber engagement portion can be obtained. As is diagrammed in FIG. 8E, moreover, a plurality of concavities B-2 may be formed at a pitch 2YO and made into a concavity group 1, and then a plurality of concavities B-2 formed at a different pitch 2YO' to make a concavity group 2, making forming surfaces that form optical fiber engagement portions between the concavity groups. In such case also, as expedient, if a mold release thin film(s) is formed on the forming surfaces, and glass or other material for forming' is press-machined, it is possible to obtain an optical fiber guide block comprising a portion wherein optical fibers are arrayed at a pitch interval of 2YO, and a portion wherein they are arrayed at 2YO'.

Embodiment 1

A mold was fabricated for press-molding a glass preform, fabricating an optical fiber guide block wherein are positioned and secured the optical input/output ends of single mode quartz glass fiber such as is widely used in the fields of optical communications and optical measurement. The number of cores in the optical fibers engaged in the optical fiber engagement portions in the optical fiber guide block is 8, with a pitch 2YO of 250 μm. The optical fiber radius is 62.5 μm. The parameters pertaining to the grindstone used in machining the concavities in the mold for forming the optical fiber engagement portions in the optical fiber guide block, and to the shape of the concavities, are listed in Table 1. Cross-sections of a mold corresponding to Table 1 are diagrammed in FIGS. 14A and 14B.

TABLE 1

Angle θ (deg)	Rmin (μm)	Rmax (μm)	dmin (μm)	dmax (μm)	R (μm)	d (μ)	Crown expos Δ(μm)	Range for Δ(μm)
40	51.04	70.52	223.1	343.4	61.0	300	10	<37.47
50	42.22	75.42	182.6	268.0	52.2	240	10	<45.36
60	29.0	81.84	154.0	216.5	39.0	190	10	<52.83
70	9.49	90.1	132.0	178.5	19.5	150	10	<59.9
74	—	94.02	124.5	165.8	19.5	140	13.3	<62.68
80	—	100.68	114.2	148.9	19.5	130	21.5	<66.71
90	—	114.28	99.1	125.0	19.5	110	33.9	<73.22

Notes

If the crown-exposure amount Δ is first determined for angle θ assuming constant pitch 2YO, R may be determined by the following equation for the range $Rmin<R<Rmax$.

$$\Delta = R[\{1/\sin(\theta/2)\}-1]-[\{YO/\tan(\theta/2)\}-\{RO/\sin(\theta/2)\}-RO]$$

d is the depth of the intersection A-4. The actual grinding depth (depth of grindstone tip apex referenced against mold material surface) will be the value obtained by subtracting the value of R[{1/sin (θ/2)}−1] from d.

The "--" symbol in the Rmin column indicates that a positive value is obtained for crown exposure if R<Rmax.

In this embodiment, the cross-section of the concavities (grindstone cross-section) is V-shaped and the cross-section of the bottoms (grindstone tip cross-section) is shaped as a circular arc. The mold material used was tungsten carbide. The grindstone used in grinding the concavities was made of diamond grit. In Table 1, R is the radius of curvature of the circular arc and d is the depth of the concavities. The surface of the mold material machined was a flat surface. A dicing machine was used in grinding the concavities. In the surface of the mold material, 9 concavities, that being the number of optical fiber cores 8 plus 1, were formed, extending in the prescribed direction at a pitch of 250 μm and parallel to one another. At this time, the positions of the concavities in the mold material were adjusted so that a position shifted by a half pitch YO, which is half the distance between the center of one concavity and the center of an adjacent concavity, forms the center of an optical fiber engagement portion. Flat forming surfaces were left remaining between the concavities in all of the molds, in a shape wherewith it is possible to form optical fiber guide blocks comprising optical fiber engagement portions having flat bottoms. When the pitch YO and the optical fiber radius RO have the values noted above, the boundary condition demanded for the shape of the grindstone tip is that angle θ be θc=74°. At angles exceeding 74°, molds can be obtained wherewith optical fiber crown exposure is possible irrespective of the cross-sectional shape of the grindstone tip.

After forming 9 concavities in this manner, a dicing machine was used to perform two-sided machining on the bottom of the outermost concavities and the ends of the portions removed by two-sided machining. After the two-sided machining, a mold release thin film(s) made of platinum was formed on the forming surfaces to yield a mold equipped with mold release thin film(s).

Embodiment 2

Next, mold machining was performed using a grindstone having a flat tip shape. In Table 2 are listed parameters pertaining to the grindstone and to the mold concavities. Mold cross-sections corresponding to Table 2 are presented in FIGS. 15A and 15B. In this figure, W is the width of the flat forming surface B-0-1 between the concavities B-2.

TABLE 2

Angle θ (deg)	Rmin (μm)	dmin (μm)	dmax (μm)	Grindstone tip W (μm)	d (μm)	Crown exposure Δ(μm)	Range for Δ(μm)
40	51.04	223.1	343.4	78.7	300	10	83.9
50	42.22	182.6	268.0	63.1	240	10	88.9
60	29.0	154.0	216.5	45.0	190	10	93.8
70	9.49	132.0	178.5	24.0	150	10	98.3
74	—	124.5	165.8	14.3	140	10	100.1
80	—	114.2	148.9	10	130	16.7	102.7
90	—	99.1	125.0	10	110	30.9	106.7

Notes

The grindstone tip width W is determined using parameter R' that satisfies the following formula.

$$\Delta = R'[\{1/\sin(\theta/2)\}-1]-[\{YO/\tan(\theta/2)\}-\{RO/\sin(\theta/2)\}-RO]$$

$$W = 2R' \tan\{(\pi-\theta)/4\}$$

When the pitch YO and the optical fiber radius RO have the values noted above, the boundary condition demanded for the shape of the grindstone tip is that angle θ be θc=74°. At angles exceeding 74°, molds can be obtained wherewith optical fiber crown exposure is possible irrespective of the cross-sectional shape of the grindstone tip. This is the same as in Embodiment 1. Using such grindstone, concavity-grinding machining and two-sided machining were performed as in Embodiment 1. However, because the bottoms of the mold concavities are flat, the precision of positioning the ends of the portions removed by two-sided machining and the bottoms of the outermost concavities was kept within the width of the flat bottoms. In this manner, shape machining was performed so as not to make a mold having any unnecessary projections. The mold material was tungsten carbide. The grindstone used was made of the same substance as in Embodiment 1. After the shape machining, a mold release thin film(s) made of platinum was formed on the forming surfaces of the mold to yield a mold equipped with mold release thin film(s).

Embodiment 3

Using the molds disclosed in Embodiments 1 and 2, an optical fiber guide block C was formed, as depicted in FIG. 16, and an 8-core optical fiber array was fabricated, as depicted in FIGS. 17A and 17B, using the optical fiber guide block C and a pressure block M. In this embodiment, as diagrammed in FIGS. 18A through 18D, a mold D that forms a pedestal C-3 that carries an optical fiber sheath in the optical fiber guide block C depicted in FIG. 16, and a mold B of the present invention, equipped with a mold release thin film(s) H, are integrated in a securing frame E to form a down die, while, separately, a cavity Z was configured, using trunk dies F to form the optical fiber guide block sides, and an up die G to form the bottom of the optical fiber guide block.

Glass preforms J having the compositions noted in Table 3 were placed inside the cavity Z, and, at the forming temperatures noted in Table 3, the glass preforms J were put under pressure by the up and down dies.

TABLE 3

Glass Composition*1							
SiO_2	4.0	4.0	23.3	4.0	4.0	4.8	13.3
GeO_2	—	5.0	—	—	—	—	—
B_2O_3	27.2	32.2	22.2	32.2	37.2	32.2	32.2
ZnO	54.5	40.5	42.5	40.5	40.2	40.7	44.0
MgO	—	—	—	—	—	—	1.0
CaO	—	—	—	—	—	—	1.5
SrO	—	—	—	—	—	—	—
BaO	—	—	—	—	—	—	—
PbO	—	—	—	—	—	—	—
(A)*2	54.5	40.5	42.5	40.5	40.2	40.7	46.5
Al_2O_3	2.5	1.0	7.5	1.0	2.5	9.0	5.5
(B)*3	88.2	82.7	95.5	77.7	82.4	86.7	97.5
Li_2O	2.5	2.5	4.5	2.5	—	2.5	2.5
La_2O	9.3	13.3	—	13.3	15.3	4.3	—
Y_2O_3	—	—	—	5.0	—	—	—
TiO_2	—	—	—	—	0.4	—	—
ZrO_2	—	1.5	—	1.5	1.5	1.5	—
Nb_2O_5	—	—	—	—	0.4	—	—
Ta_2O_5	—	—	—	—	—	5.0	—
Sb_2O_3*4	—	—	0.5	—	—	—	—
Parameter							
Transition point	465° C.	500° C.	470° C.	500° C.	530° C.	510° C.	495° C.
Yield point	495° C.	540° C.	500° C.	530° C.	555° C.	540° C.	520° C.
Mean CTE*5	64	63	62	66	67	64	66
UV Perm.*6	81%	85%	91%	84%	80%	81%	83%
Forming temp	545° C.	593° C.	553° C.	584° C.	595° C.	592° C.	573° C.

*1 Values for each component are in values of wt %.
*2 Represents Zno, MgO, CaO, SrO, BaO, and PbO total content.
*3 Represents SiO_2, GeO_2, B_2O_3, RO(R = Zn, Mg, Ca, Sr, Ba, Pb), and Al_2O_3 total content.
*4 Represents amount added outside composition proportions.
*5 Represents mean coefficient of thermal expansion from room temperature to 400° C., in $\times 10^{-7}/°$ C. units.
*6 Represents transmissivity of UV radiation of 350 nm wavelength through a test piece 2 mm in thickness.

After sufficient glass packing, the molding K was removed from the die to yield an optical fiber guide block C. Into the optical fiber engagement portions C-1 of the optical fiber guide block C fabricated as noted above, 8 quartz-glass single mode fibers were engaged and secured, as diagrammed in FIGS. 17A and 17B. Then, with the optical fiber sheath mounted on the pedestal C-3, a UV-hardening adhesive was applied, and the optical fiber sides were pressed down with a glass pressure block M having a flat pressing surface M-1. The adhesive was then irradiated with UV rays through the glass, thereby hardening the adhesive and setting the optical fibers. The light input/output end surfaces of the optical fiber array fabricated in this manner were optically polished to complete the optical fiber array.

After this polishing, the vicinity of the secured optical fibers so secured was examined under an electron microscope, from the end surfaces. This confirmed that all eight of the optical fibers were supported at three points. The optical fiber array was then subjected to a thermal cycle in which it was found that the total optical-connection loss fluctuation amplitude was within 0.3 dB. No changes in the location accuracy of the optical fibers were observed after these tests, nor were seen any changes in the condition wherein the optical fibers were held and secured by three-point support. When materials other than tungsten carbide, as noted above, were used as the mold material, the same good results were obtained. Thus, by employing the present invention, optical fiber crown exposure can be effected, making it possible to secure the ends of optical fibers by three-point support, and thereby enabling optical fibers to be stably held and secured with high location accuracy.

If the radius of the imaginary circle that forms the minimum radius of curvature of concavities shaped as circular arcs in a mold is within the expanded range, as provided, it is possible to effect stable holding and securing at high location accuracy, even without employing three-point support, and to keep the optical-connection loss in an optical fiber array within allowable limits.

What is claimed is:

1. A method of fabricating a mold for fabricating optical fiber guide blocks, for the purpose of molding by a press-molding process at least the optical fiber engagement portions of said optical fiber guide blocks, said optical fiber guide blocks comprising said optical fiber engagement portion(s) for the purpose of positioning and aligning optical fibers at a fixed pitch, wherein a grindstone is used comprising two main grinding surfaces that machine formed surfaces that support the sides of said optical fibers; and

a shape wherein the angle θ subtended by the two tangent lines which touch said two main grinding surfaces in a cross-section perpendicular to said main grinding surfaces constitutes an angle that is equal to or smaller than θc which satisfies the relationship noted below; and

a contour of the tip that connects said two main grinding surfaces is contained within an area bounded by said two tangent lines and by a line that is tangent to an imaginary circle and perpendicular to the straight line connecting the intersection of said two tangent lines with the center of said imaginary circle, and that passes between said intersection and the center of said imaginary circle, when said imaginary circle, of radius Rmin as defined below, is inscribed in the area that is in the bight of said two tangent lines:

$$\theta c = 2\tan^{-1}\{(S^2-1)/2S\}$$

where:

S=YO/RO

Rmin=[RO+{RO/sin (θ/2)}−{YO/tan (θ/2)}]/[1−{1/sin (θ/2)}];

RO is the optical fiber radius; and

YO is half the pitch length of the optical fiber engagement portion; and said method comprises:

forming concavities extending in a prescribed direction, of such depth that said intersection between said two tangent lines will be at a position deeper than dmin, by a grinding process, on the flat surface of the mold material, at said pitch, in a direction perpendicular to said prescribed direction, in a number that is the number of said optical fiber engagement portions plus 1 wherein

$$d\min = [YO - RO\cdot\tan\{(\pi-\theta)/4\}]/\tan(\theta/2).$$

2. A method of fabricating a mold for fabricating optical fiber guide blocks, for the purpose of molding by press-molding process at least the optical fiber engagement portions of said optical fiber guide blocks; said optical fiber guide blocks comprising

groove-shaped optical fiber engagement portion(s) for the purpose of positioning optical fibers; wherein a grindstone is used comprising two main grinding surfaces that machine formed surfaces that support the sides of said optical fibers; and

a shape wherein the angle θ subtended by the two tangent; lines which touch said two main grinding surfaces in a cross-section perpendicular to said main grinding surfaces constitutes an angle that is equal to or smaller than θc which satisfies the relationship noted below; and

a contour of the tip that connects said two main grinding surfaces is contained within an area bounded by said two tangent lines and by a line that is tangent to an imaginary circle and perpendicular to the straight line connecting the intersection of said two tangent lines with the center of said imaginary circle, and that passes between said intersection and the center of said imaginary circle, when said imaginary circle, of radius Rmin as defined below, is inscribed in the area that is in the bight of said two tangent lines:

$$\theta c = 2\tan^{-1}\{(S^2-1)/2S\}$$

where:

S=YO/RO

Rmin=[RO+{RO/sin (θ/2)}−{YO/tan (θ/2)}]/[1−{1/sin (74 /2)}];

RO is the optical fiber radius; and

YO is half the pitch length of the optical fiber engagement portion; and said method comprises the steps of

forming a plurality of concavities extending in a prescribed direction, of such depth that said intersection between said two tangent lines will be at a position deeper than dmin, by a grinding process, on the flat surface of the mold material, in a direction perpendicular to said prescribed direction, and such that the interval between at least two of said concavities becomes 2YO; wherein

$$d\min = [YO - RO\cdot\tan\{(\pi-\theta)/4\}]/\tan(\theta/2).$$

3. The method of fabricating a mold for fabricating optical fiber guide blocks, according to claim 1, wherein concavities are machined at a depth such that said intersection between said two tangent lines becomes a position that is shallower than dmax, as defined below:

$$d\max = YO/\tan(\theta/2).$$

4. The method of fabricating a mold for fabricating optical fiber guide blocks, according to claim 3, comprising: a process for machining such that, after grinding-machining said concavities, outside of the two grooves positioned outermost among said grooves, the portions which connect to the bottoms of at least said two grooves are in the same plane as said bottoms of said two grooves.

5. A method of fabricating a mold for fabricating optical fiber guide blocks, for the purpose of molding by press-molding process at least the optical fiber engagement portions of said optical fiber guide blocks, said optical fiber guide blocks comprising said optical fiber engagement portion(s) for the purpose of positioning and aligning optical fibers at a fixed pitch, wherein a grindstone is used comprising two main grinding surfaces that machine formed surfaces that support the sides of said optical fibers; and

a shape wherein the angle θ subtended by the two tangent lines which touch said two main grinding surfaces in a cross-section perpendicular to said main grinding surfaces constitutes an angle that is not greater than θc which satisfies the relationship noted below; and

a contour of the tip that connects said two main grinding surfaces is contained within an area bounded by said two tangent lines and by a line that is tangent to an imaginary circle and perpendicular to the straight line connecting the intersection of said two tangent lines with the center of the imaginary circle, and that passes between said intersection and the center of said imaginary circle, when said imaginary circle, of radius Rmin as defined below, is inscribed in the area that is in the bight of said two tangent lines:

$$\theta c = 2\tan^{-1}\{S^2-1)/2S\},$$

where:

S=YO/RO

Rmin=[RO+{RO/sin (θ/2)}−{YO/tan (θ/2)}]/[1−{1/sin (θ/2)}];

RO is the optical fiber radius; and

2YO is the interval between the concavities when at least two groove-shaped concavities are formed by the grindstone in a mold material that is to be the mold, so as to form the optical fiber engagement portion(s) between the concavities; and said method comprises:

forming concavities extending in a prescribed direction, of such depth that said intersection between said two tangent lines will be at a position deeper than dmin, by a grinding process, on the flat surface of the mold material, at said pitch, in a direction perpendicular to said prescribed direction, in a number that is the number of said optical fiber engagement portions plus 1, wherein

$dmin=\{YO-RO\cdot\tan\{(\pi-\theta)/4\}\}/\tan(\theta/2)$.

6. A method of fabricating a mold for fabricating optical fiber guide blocks, for the purpose of molding by press-molding process at least the optical fiber engagement portions of said optical fiber guide blocks, said optical fiber guide blocks comprising said optical fiber engagement portion(s) for the purpose of positioning and aligning optical fibers at a fixed pitch, wherein a grindstone is used comprising two main grinding surfaces that machine formed surfaces that support the sides of said optical fibers; wherein the angle θ subtended by the two tangent lines in a cross-section perpendicular to said main grinding surfaces constitutes an angle that exceeds θc which satisfies the relationship noted below:

$$\theta c=2\tan^{-1}\{(S2-1)/2S\},$$

where:

S=YO/RO;

RO is the optical fiber radius; and

YO is half the pitch length of the optical fiber engagement portion; and said method comprises:

forming concavities extending in a prescribed direction, of such depth that said intersection between said two tangent lines will be at a position deeper than dmin, by a grinding process, on the flat surface of the mold material, at said pitch, in a direction perpendicular to said prescribed direction, in a number that is the number of said optical fiber engagement portions plus 1, wherein

$$dmin=\{YO-RO\cdot\tan(\{(\pi-\theta)/4\}\}/\tan(\theta/2).$$

7. A method of fabricating a mold for fabricating optical fiber guide blocks, for the purpose of molding by press-molding process at least the optical fiber engagement portions of said optical fiber guide blocks, said optical fiber guide blocks comprising said optical fiber engagement portion(s) for the purpose of positioning and aligning optical fibers at a fixed pitch, wherein a grindstone is used comprising two main grinding surfaces that machine formed surfaces that support the sides of said optical fibers; wherein the angle θ subtended by the two tangent lines in a cross-section perpendicular to said main grinding surfaces constitutes an angle that exceeds θc which satisfies the relationship noted below:

$$\theta c=2\tan^{-1}\{(S2-1)/2S\},$$

where:

S=YO/RO;

RO is the optical fiber radius; and

2YO is the interval between the concavities when at least two groove-shaped concavities are formed by the grindstone in a mold material that is to be the mold, so as to form the optical fiber engagement portion between the concavities; and said method comprises:

forming concavities extending in a prescribed direction, of such depth that said intersection between said two tangent lines will be at a position deeper than dmin, by a grinding process, on the flat surface of the mold material, at said pitch, in a direction perpendicular to said prescribed direction, in a number that is the number of said optical fiber engagement portions plus 1, wherein

$$dmin=\{YO-RO\cdot\tan\{(\pi-\theta)/4\}\}/\tan(\theta/2).$$

8. A method of fabricating a mold for fabricating optical fiber guide blocks, for the purpose of molding by press-molding process at least the optical fiber engagement portions of said optical fiber guide blocks, said optical fiber guide blocks comprising:

groove-shaped optical fiber engagement portion(s) for the purpose of positioning optical fibers; wherein a grindstone is used comprising two main grinding surfaces that machine formed surfaces that support the sides of said optical fibers; and

a shape wherein the angle θ subtended by the two tangent lines which touch said two main grinding surfaces in a cross-section perpendicular to said main grinding surfaces constitutes an angle that is not greater than θc which satisfies the relationship noted below; and

a contour of the tip that connects said two main grinding surfaces is contained within an area bounded by said two tangent lines and by a line that is tangent to an imaginary circle and perpendicular to the straight line connecting the intersection of said two tangent lines with the center of the imaginary circle, and that passes between said intersection and the center of said imaginary circle, when said imaginary circle, of radius Rmin as defined below, is inscribed in the area that is in the bight of said two tangent lines:

$$\theta c=2\tan^{-1}\{(S2-1)/2S\},$$

where:

S=YO/RO;

Rmin=[RO+{RO/sin (θ/2)}−{YO/tan (θ/2)}]/[1−{1/sin (θ/2)}];

RO is the optical fiber radius; and

2YO is the interval between the concavities when at least two groove-shaped concavities are formed by the grindstone in a mold material that is to be the mold, so as to form the optical fiber engagement portion(s) between the concavities; and said method comprises the steps of forming a plurality of concavities extending in a prescribed direction, of such depth that said intersection between said two tangent lines will be at a position deeper than dmin, by a grinding process, on the flat surface of the mold material, in a direction perpendicular to said prescribed direction, and such that the interval between at least two of said concavities becomes 2YO; wherein

$$dmin=\{YO-RO\cdot\tan\{(\pi-\theta)/4\}\}/\tan(\theta/2).$$

9. A method of fabricating a mold for fabricating optical fiber guide blocks, for the purpose of molding by press-molding process at least the optical fiber engagement portions of said optical fiber guide blocks, said optical fiber guide blocks comprising:

groove-shaped optical fiber engagement portion(s) for the purpose of positioning optical fibers; wherein a grindstone is used comprising two main grinding surfaces that machine formed surfaces that support the sides of said optical fibers; wherein the angle 0 subtended by the two tangent lines in a cross-section perpendicular to said main grinding surfaces constitutes an angle that exceeds θc which satisfies the relationship noted below:

$$\theta c=2\tan^{-1}\{(S^2-1)/2S\},$$

where:

RO is the optical fiber radius; and

YO is half the pitch length of the optical fiber engagement portion; and sad method comprises the steps of forming a plurality of concavities extending in a prescribed direction, of such depth that said intersection between said two tangent lines will be at a position deeper than dmin, by a grinding process, on the flat surface of the mold material, in a direction perpendicular to said prescribed direction, and such that the interval between at least two of said concavities becomes 2YO; wherein

$$dmin=\{YO-RO\cdot\tan\{(\pi-\theta)/4\}\}/\tan(\theta/2).$$

10. A method of fabricating a mold for fabricating optical fiber guide blocks, for the purpose of molding by press-molding process at least the optical fiber engagement portions of said optical fiber guide blocks, said optical fiber guide blocks comprising:

groove-shaped optical fiber engagement portion(s) for the purpose of positioning optical fibers; wherein a grindstone is used comprising two main grinding surfaces that machine formed surfaces that support the sides of said optical fibers; wherein the angle θ subtended by the two tangent lines in a cross-section perpendicular to said main grinding surfaces constitutes an angle that exceeds θc which satisfies the relationship noted below:

$$\theta c=2\tan^{-1}\{(S^2-1)/2S\},$$

where:

S=YO/RO;

RO is the optical fiber radius; and

2YO is the interval between the concavities when at least two groove-shaped concavities are formed by the grindstone in a mold material that is to be the mold, so as to form the optical fiber engagement portion between the concavities; and said method comprises the steps of forming a plurality of concavities extending in a prescribed direction, of such depth that said intersection between said two tangent lines will be at a position deeper than dmin, by a grinding process, on the flat surface of the mold material, in a direction perpendicular to said prescribed direction, and such that the interval between at least two of said concavities becomes 2YO; wherein

$$dmin=\{YO-RO\cdot\tan\{(\pi-\theta)/4\}\}/\tan(\theta/2).$$

11. The method of fabricating a mold for fabricating optical fiber guide blocks, according to claim **2**, wherein concavities are machined at a depth such that said intersection between said two tangent lines becomes a position that is shallower than dmax, as defined below:

$$dmax=YO/\tan(\theta/2).$$

12. The method of fabricating a mold for fabricating optical fiber guide blocks, according to claim **11**, comprising: a process for machining such that, after grinding-machining said concavities, outside of the two grooves positioned outermost among said grooves, the portions which connect to the bottoms of at least said two grooves are in the same plane as said bottoms of said two grooves.

13. A method of fabricating optical fiber guide blocks comprising:

using a mold for fabricating optical fiber guide blocks that comprises:

convexities that extend in the longitudinal dimension of the forming surface; and

concavities that extend in the longitudinal dimension, arrayed with said convexities sandwiched in between them;

wherein the tangent lines at the points where are formed the portions of the two sloping surfaces that configure said concavities in a cross-section perpendicular to the longitudinal dimension of said concavities, which portions are to support optical fibers, subtend an angle θ that is equal to or smaller than θc which satisfies the relationship noted below;

the perpendicular cross-sectional shape of said concavities is such that the contour thereof is contained within an area bounded by the two tangent lines that touch said sloping surfaces and by a line that is tangent to an imaginary circle and perpendicular to the straight line connecting the intersection of said two tangent lines with the center of said imaginary circle, and that passes between said intersection and said center of said imaginary circle, when said imaginary circle, of radius Rmin as defined below, is inscribed in the area that is in the bight of said two tangent lines;

the depth of said concavities is such that said intersection of said two tangent lines is at a position deeper than dmin, as defined below; and

one or other of said sloping surfaces that form said concavities is what forms the surfaces that support said optical fibers in said optical fiber engagement portions:

$$\theta c=2\tan^{-1}\{S^2-1)/2S\},$$

where:

S=YO/RO;

Rmin=[RO+{RO/sin (θ/2)}−{YO/tan (θ/2)}]/[1−{1/sin (θ/2)}];

dmin=[YO−RO·tan {(π−θ)/4}]/tan (θ/2);

RO is the optical fiber radius; and

2YO is the interval between the concavities arrayed so as to sandwich the convexities between them; and

press molding the raw material to be molded under heat.

14. A method of fabricating optical fiber guide blocks comprising:

using a mold for fabricating optical fiber guide blocks that comprises:

a plurality of concavities that extend in one direction in a forming surface;

wherein the tangent lines at the points where the portions that are to support said optical fibers at the two sloping surfaces which configure the concavities, in a cross-section that is perpendicular to the longitudinal dimension of said concavities, subtend an angle θ that exceeds θc which satisfies the relationship noted below;

the depth of said concavities is such that said intersection of said tangent lines is at a position deeper than dmin, as defined below; and

the forming surfaces between said concavities are what form optical fiber engagement portions:

$$\theta c = 2 \tan^{-1} \{S^2-1)/2S\},$$

where:

S=YO/RO;

dmin=[YO−RO·tan {(π−θ)/4}]/tan (θ/2);

RO is the optical fiber radius; and

YO is half the pitch length of the optical fiber engagement portion; and

press molding the raw material to be molded under heat.

15. A method of fabricating optical fiber guide blocks comprising:

using a mold for fabricating optical fiber guide blocks that comprises:

convexities that extend in the longitudinal dimension of a forming surface; and

concavities that extend in the longitudinal dimension, arrayed with the convexities sandwiched in between them; wherein the tangent lines at the points where are formed the portions of the two sloping surfaces that configure said concavities in a cross-section perpendicular to the longitudinal dimension of said concavities, which portions are to support optical fibers, subtend an angle θ that exceeds θc which satisfies the relationship noted below;

the depth of said concavities is such that the intersection of said tangent lines is at a position deeper than dmin, as defined below; and

one or other of the sloping surfaces that form the concavities is what forms the surfaces that support said optical fibers in the optical fiber engagement portions:

$$\theta c = 2 \tan^{-1} \{S^2-1)/2S\},$$

where:

S=YO/RO;

dmin=[YO−RO·tan {(π−θ)/4}]/tan (θ/2);

RO is the optical fiber radius; and

2YO is the interval between the concavities arrayed so as to sandwich the convexities between them; and

press molding the raw material to be molded under heat.

* * * * *

US006510109B2

(12) **United States Patent**
Ohmori

(10) **Patent No.: US 6,510,109 B2**
(45) **Date of Patent: Jan. 21, 2003**

(54) **MAGNETIC HEAD INCLUDING STEPPED CORE AND MAGNETO-OPTICAL RECORDING DEVICE USING THE SAME**

(75) Inventor: **Takashi Ohmori**, Tokyo (JP)

(73) Assignee: **Sony Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/926,548**

(22) PCT Filed: **Mar. 9, 2001**

(86) PCT No.: **PCT/JP01/01881**

§ 371 (c)(1),
(2), (4) Date: **Nov. 19, 2001**

(87) PCT Pub. No.: **WO01/71712**

PCT Pub. Date: **Sep. 27, 2001**

(65) **Prior Publication Data**

US 2002/0163862 A1 Nov. 7, 2002

(30) **Foreign Application Priority Data**

Mar. 17, 2000 (JP) 2000-081852

(51) **Int. Cl.**[7] **G11B 11/00**

(52) **U.S. Cl.** **369/13.23**; 369/13.17; 360/234.7

(58) **Field of Search** 369/13.17, 13.14, 369/13.23, 253, 13.2, 77.2, 256; 360/122, 123, 125, 129, 119, 59, 234.7, 323, 319, 244.4, 245.9, 246.2, 234.3, 234.6, 245.3, 236.6

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,107,471 A	*	4/1992	Miyake et al.	360/119 X
5,260,921 A	*	11/1993	Shibuya et al.	360/59 X
5,572,490 A	*	11/1996	Kazama	360/234.7
5,703,840 A	*	12/1997	Kazama	360/59 X

FOREIGN PATENT DOCUMENTS

JP	2-79201		3/1990
JP	4-105234		4/1992
JP	6-124401		5/1994
JP	6-176429		6/1994
JP	8-45129		2/1996
JP	10188202	*	7/1998

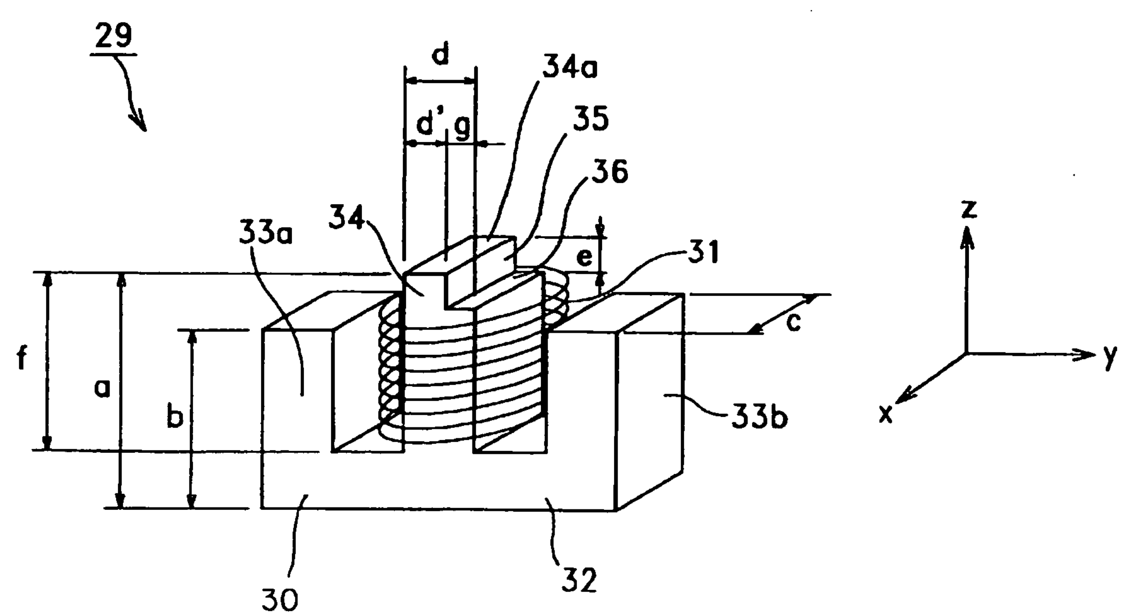
* cited by examiner

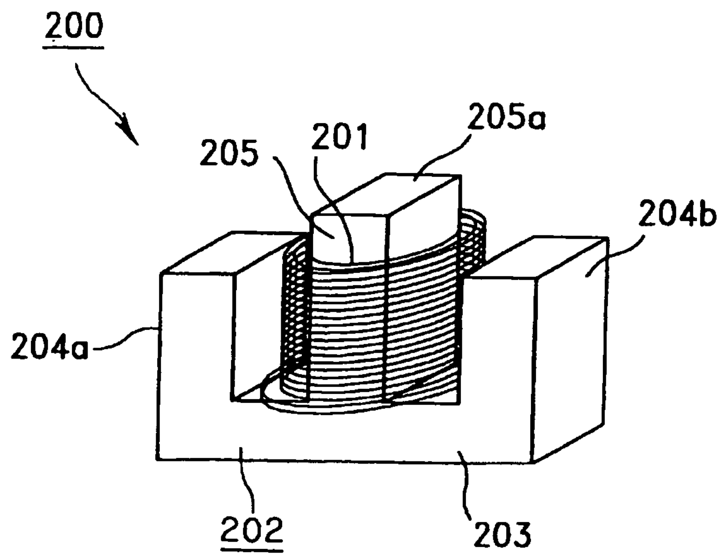
Primary Examiner—Ali Neyzari
(74) *Attorney, Agent, or Firm*—Oblon, Spivak, McClelland, Maier & Neustadt, P.C.

(57) **ABSTRACT**

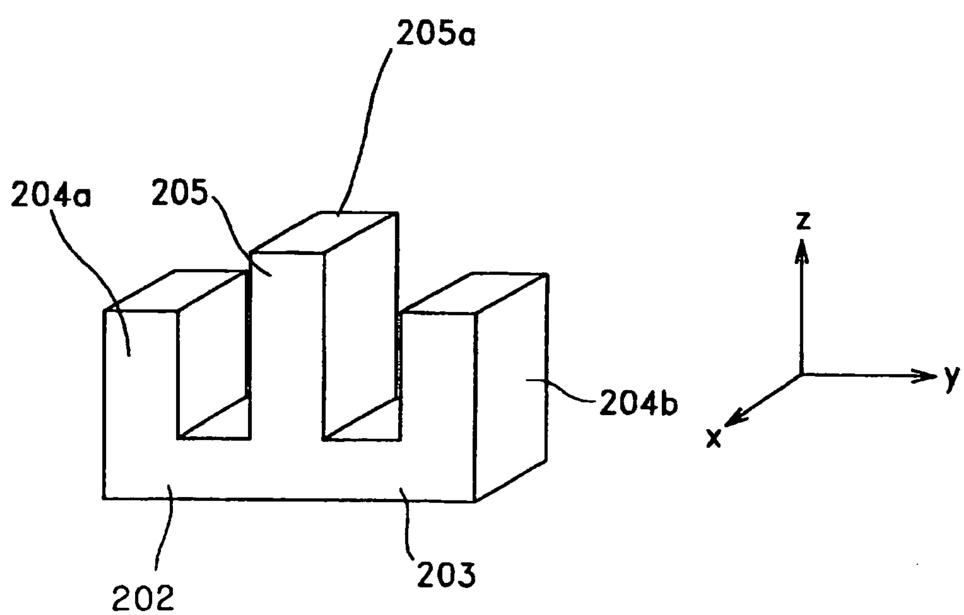
A magnetic head for supplying a magnetic field in recording an. information signal to a recording medium is provided. This magnetic head has a substantially. prism-shaped magnetic core portion having a distal end portion cut out to form a step, the magnetic core portion being form so that the cross-sectional area of the distal end portion is smaller than the cross-sectional area of a proximal end portion, and a coil wound on the outer circumferential surface of the magnetic core portion, wherein the length of one side of the distal end portion is not less than 0.3 mm and not more than 0.45 mm, and the length of the other side orthogonal to the one side is not less than 0.4 mm and not more than 0.55 mm.

6 Claims, 17 Drawing Sheets





RELATED ART
FIG. 1



RELATED ART
FIG. 2

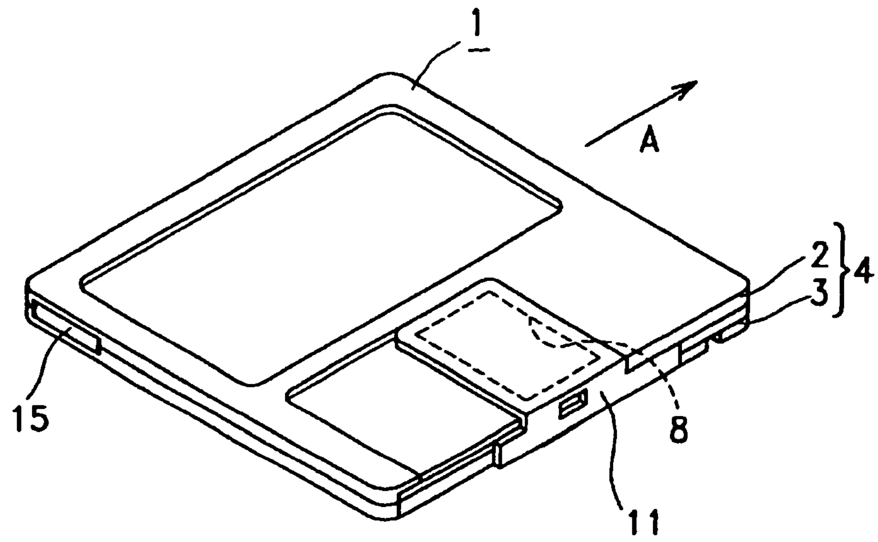


FIG. 3

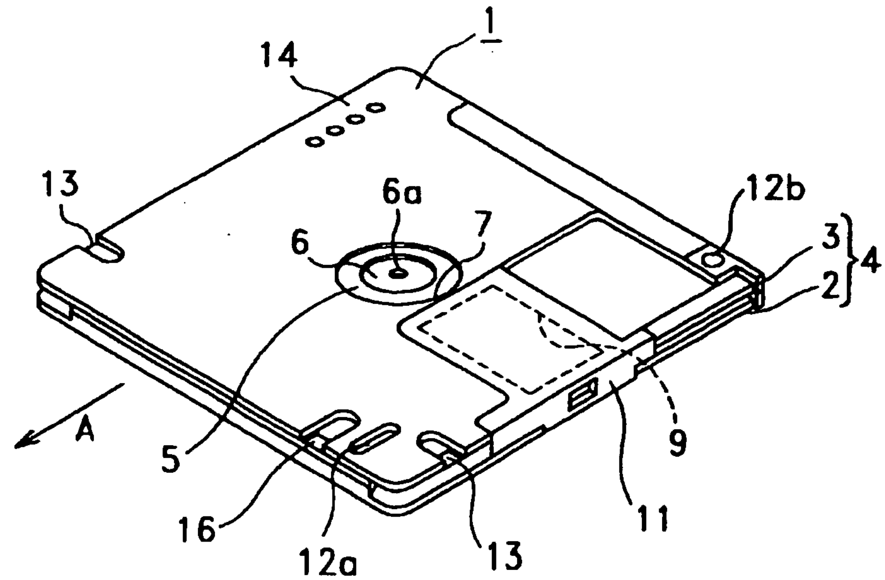


FIG. 4

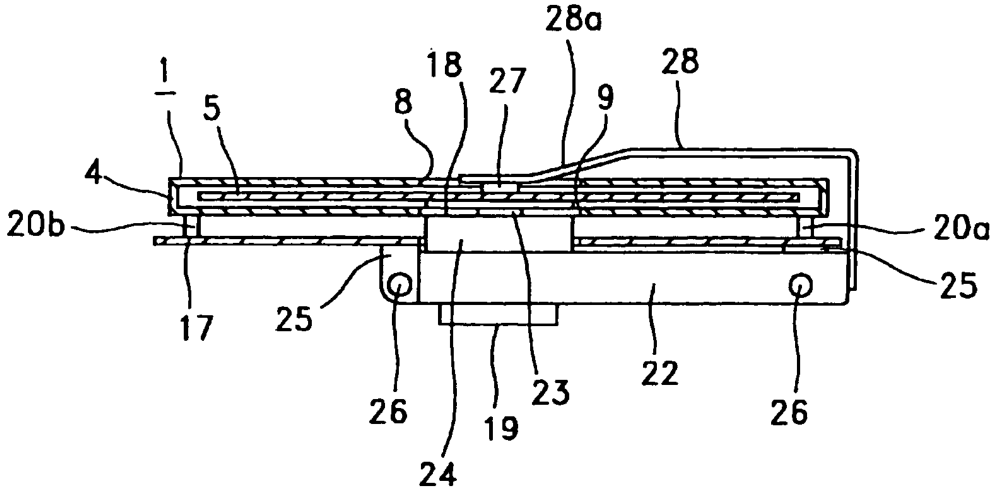

28a
28
27
18
9
1
5
8
4
20b
20a
25
17
25
26
24
23
19
22
26

FIG. 5

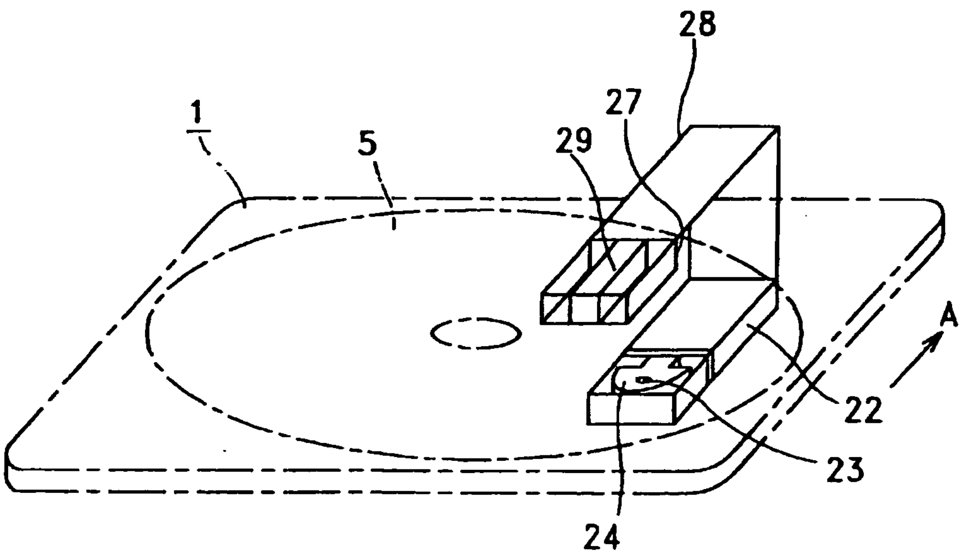

28
27
29
1
5
A
22
23
24

FIG. 6

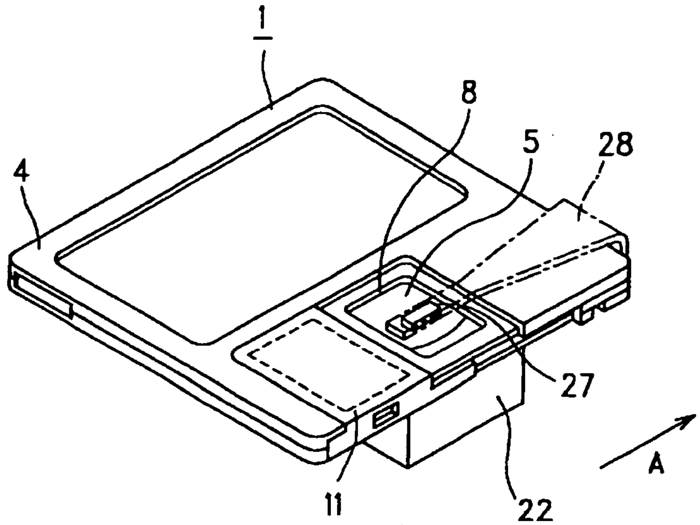


FIG. 7

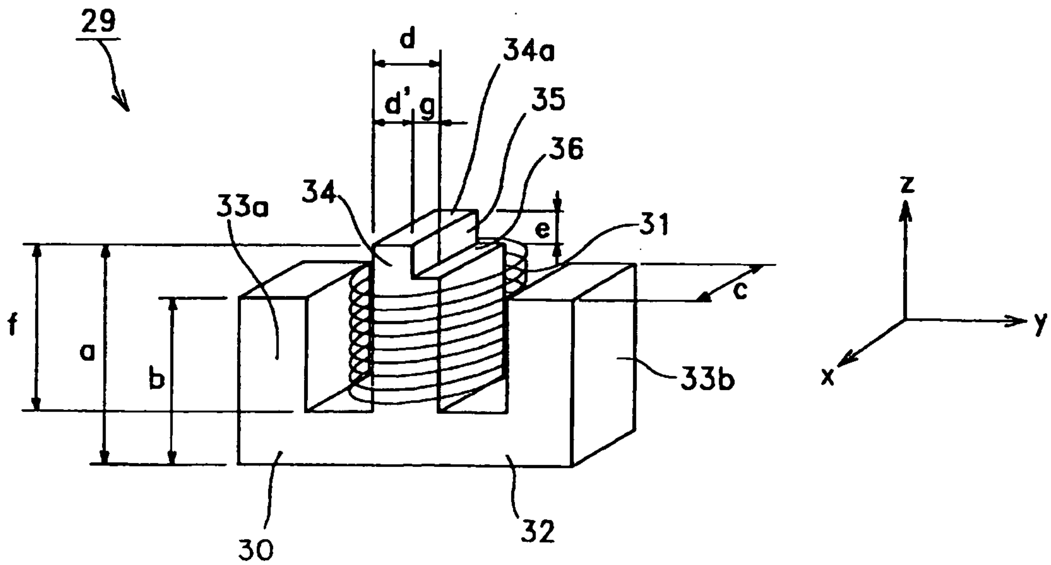


FIG. 8

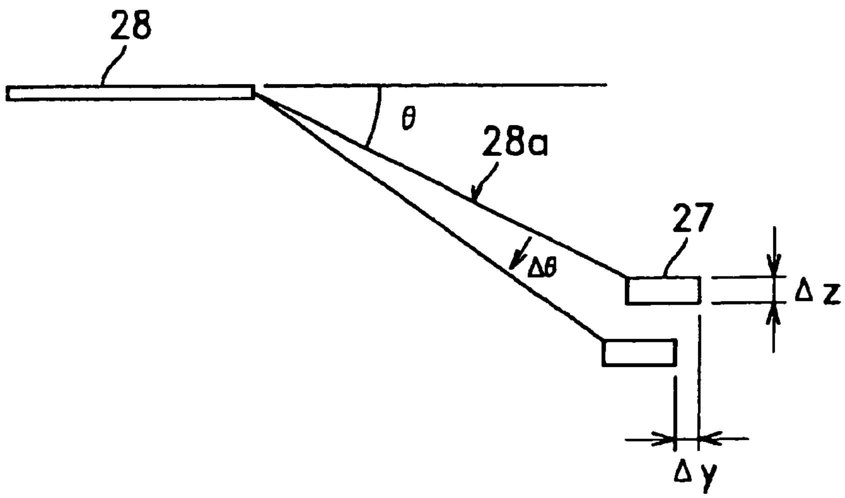


FIG. 9

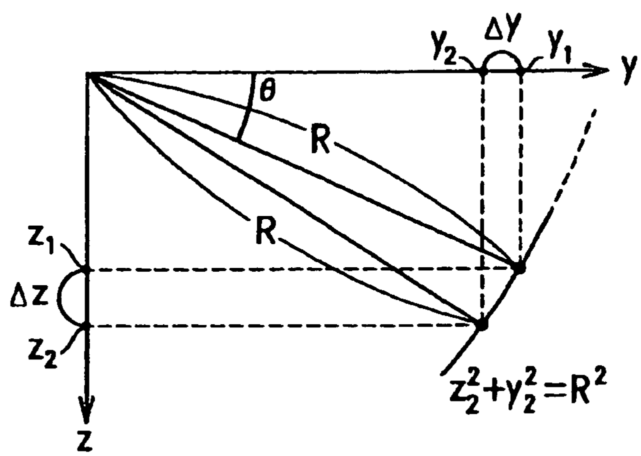
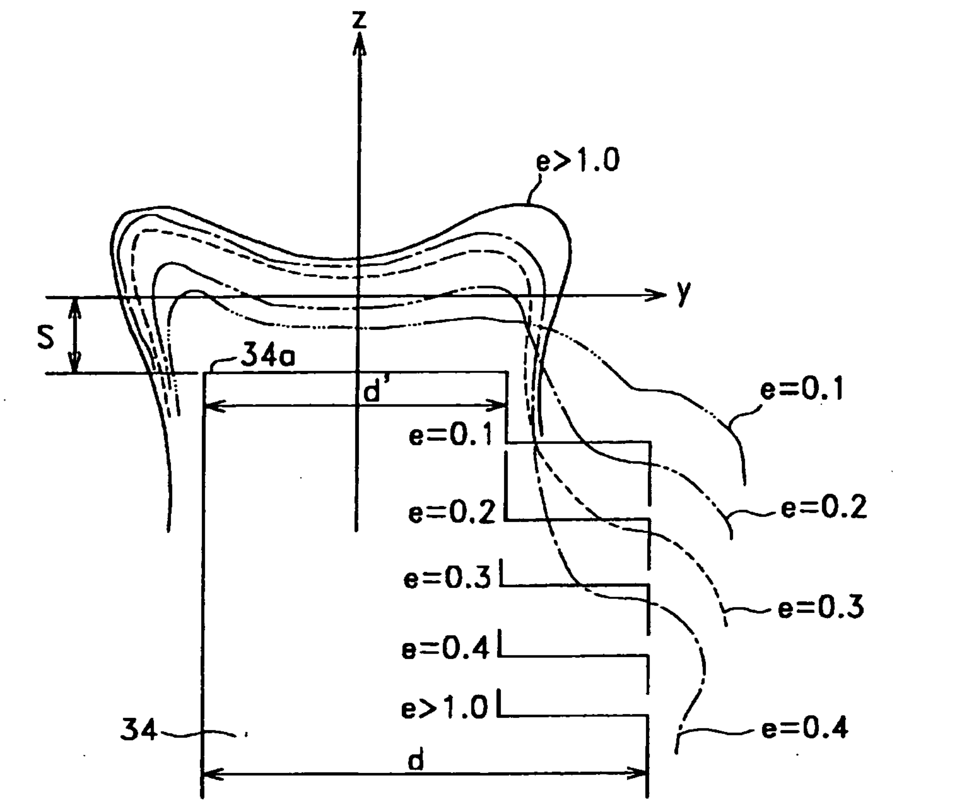
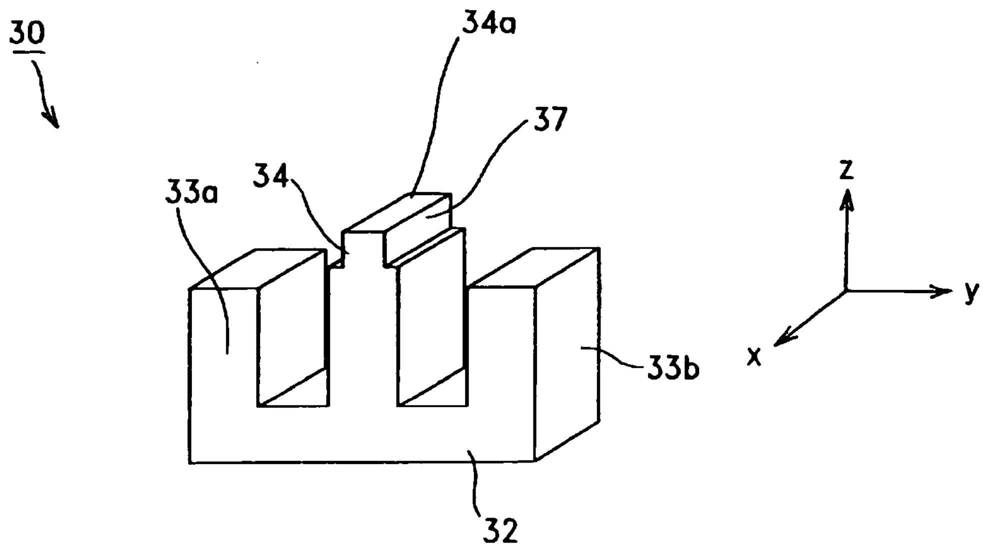


FIG. 10



z
y
e>1.0
S
34a
d'
e=0.1
e=0.1
e=0.2
e=0.2
e=0.3
e=0.3
e=0.4
e=0.4
e>1.0
34
d

FIG. 11



30
34a
37
34
33a
z
y
x
33b
32

FIG. 12

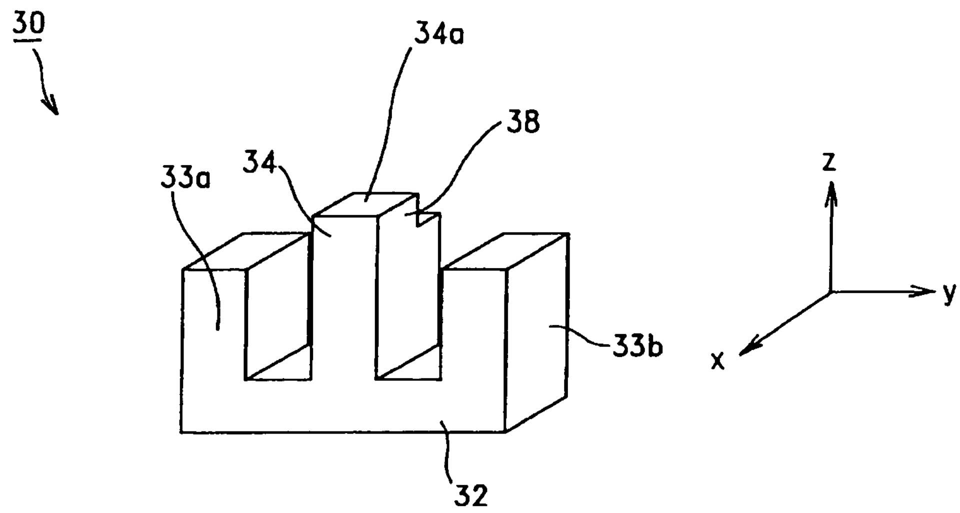


FIG. 13

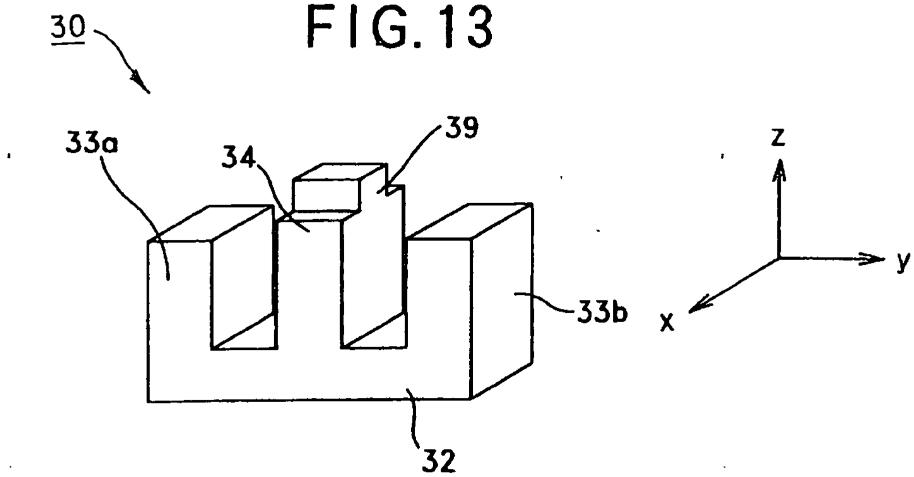


FIG. 14

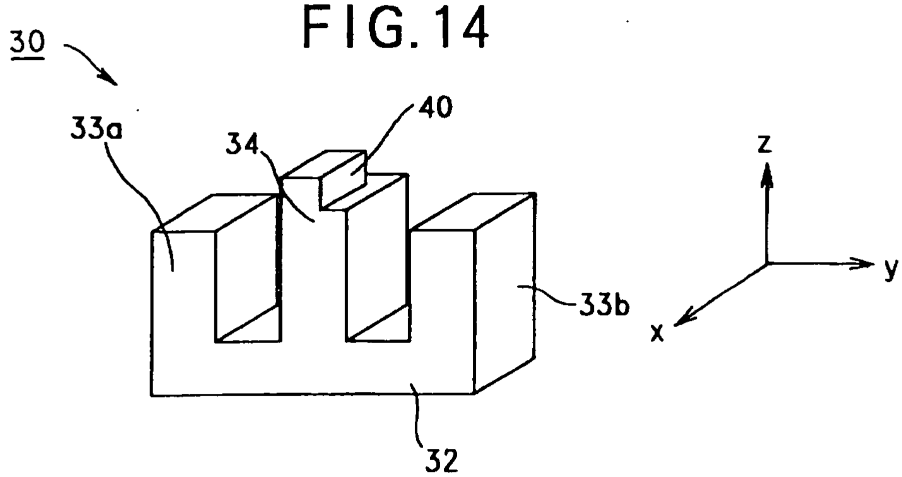


FIG. 15

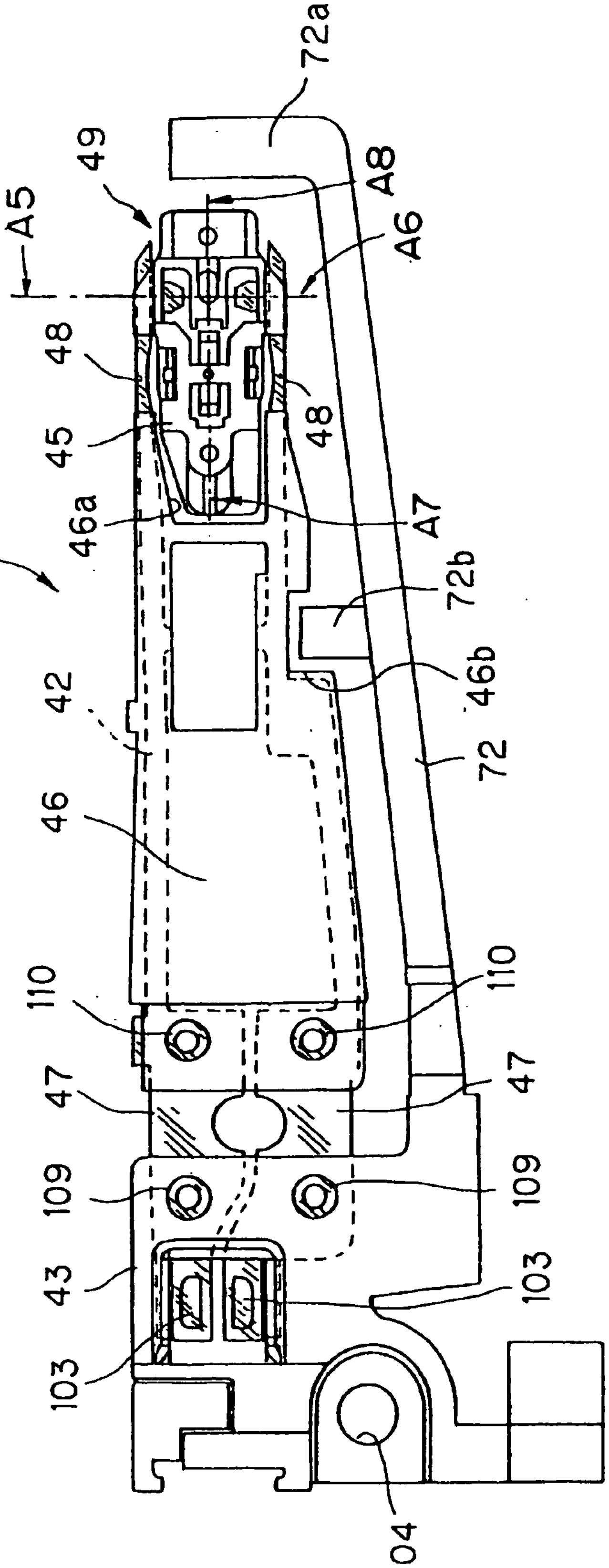

72a
49
A5
A8
A6
48
48
45
46a
A7
41
72b
46b
42
72
46
110
110
47
47
109
109
43
103
103
104

FIG. 16

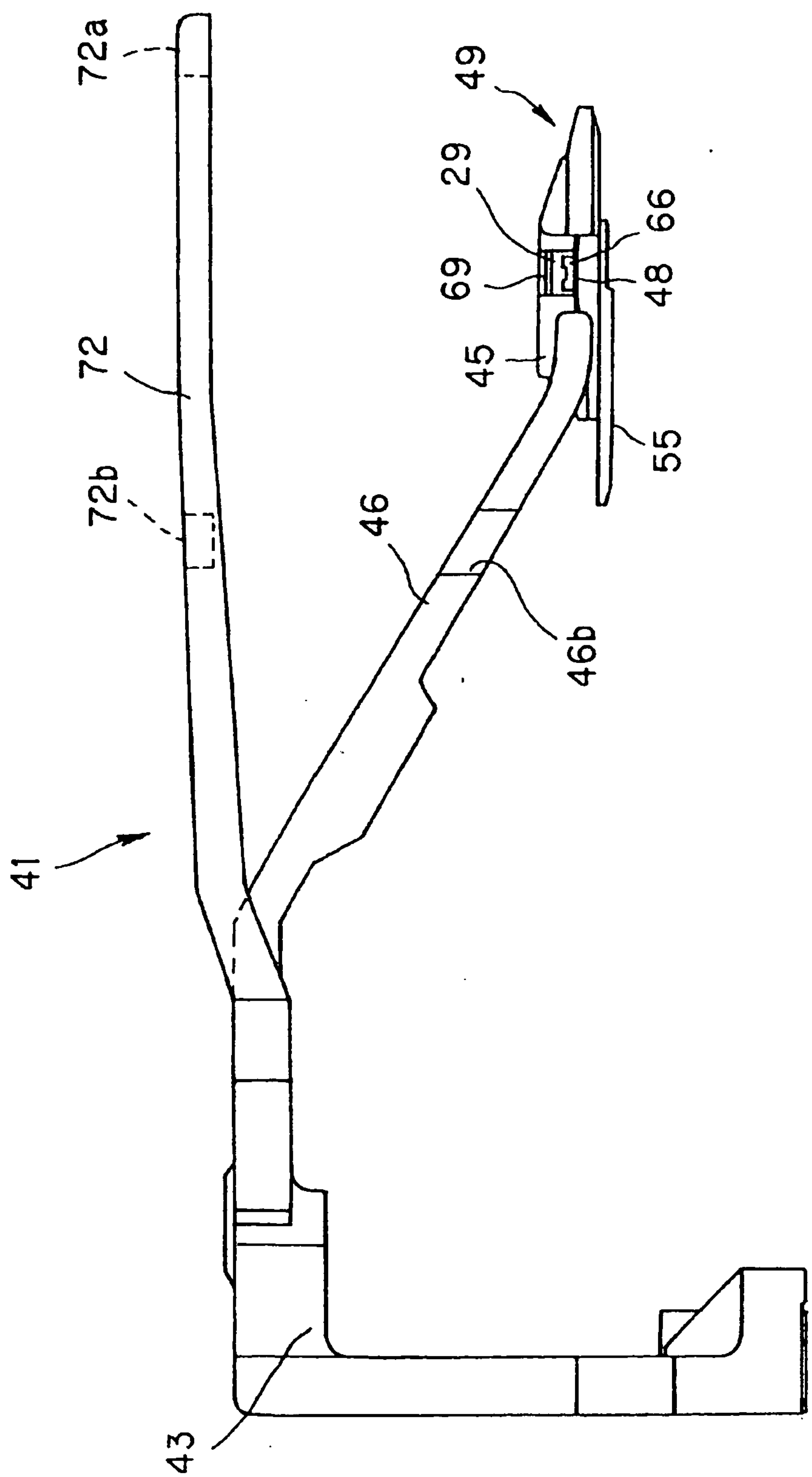


FIG.17

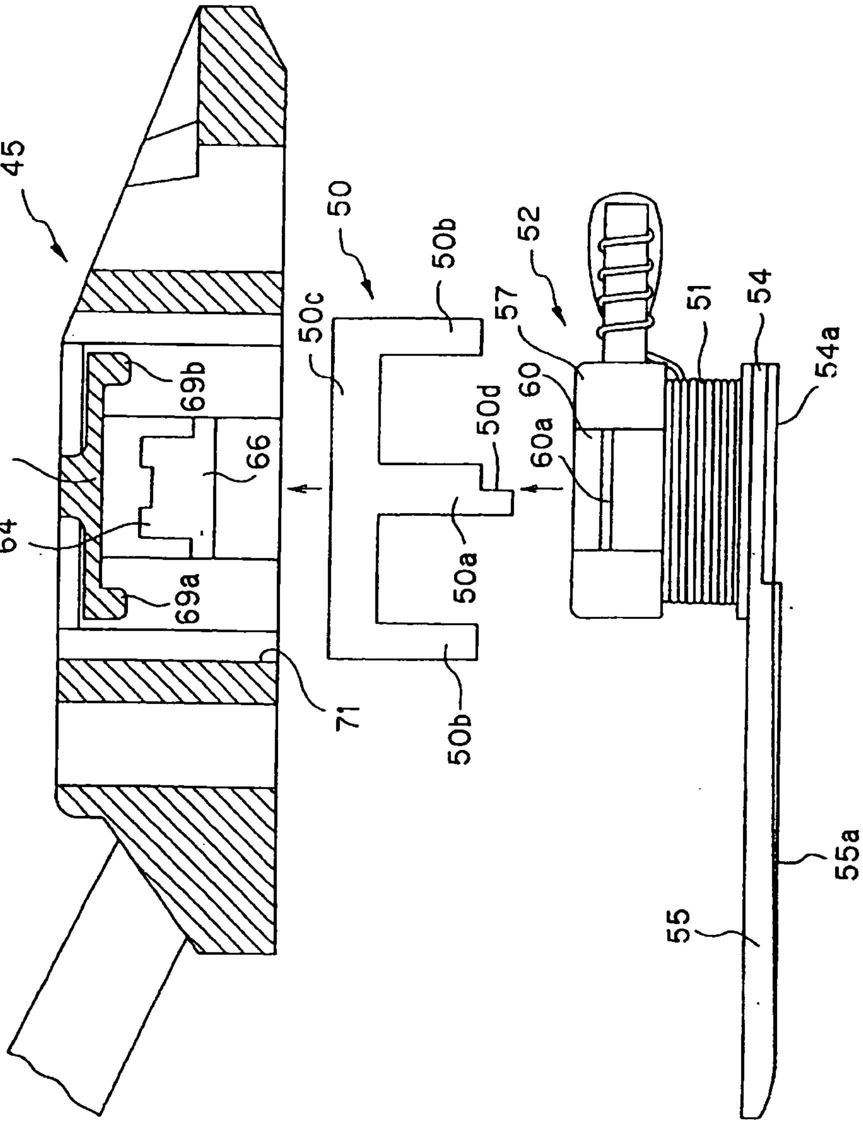

45
50
50b
50c
50d
50a
50b
52
57
60
60a
51
54
54a
55a
55
69
69b
66
64
69a
71

FIG. 18

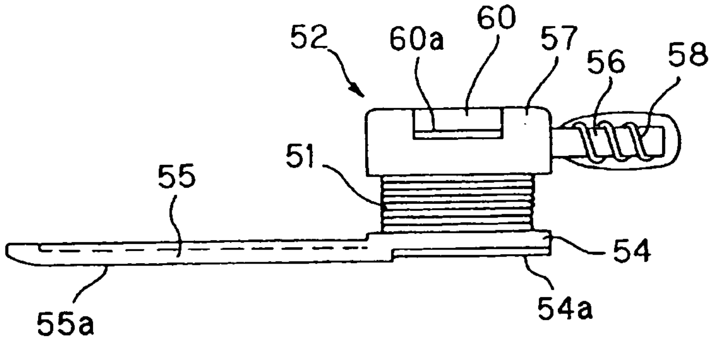


FIG. 19

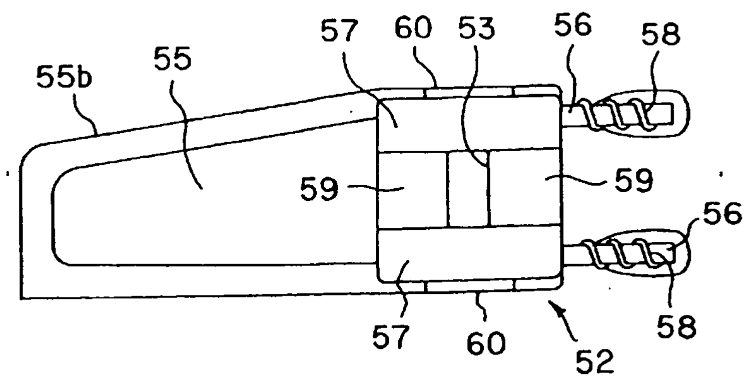


FIG. 20

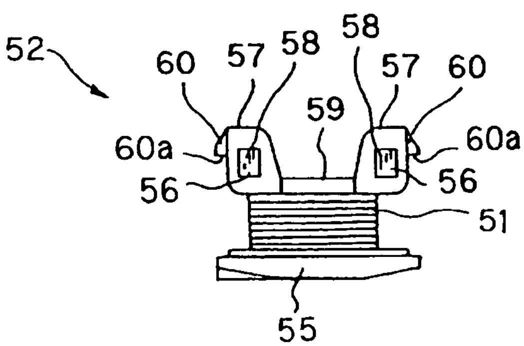


FIG. 21

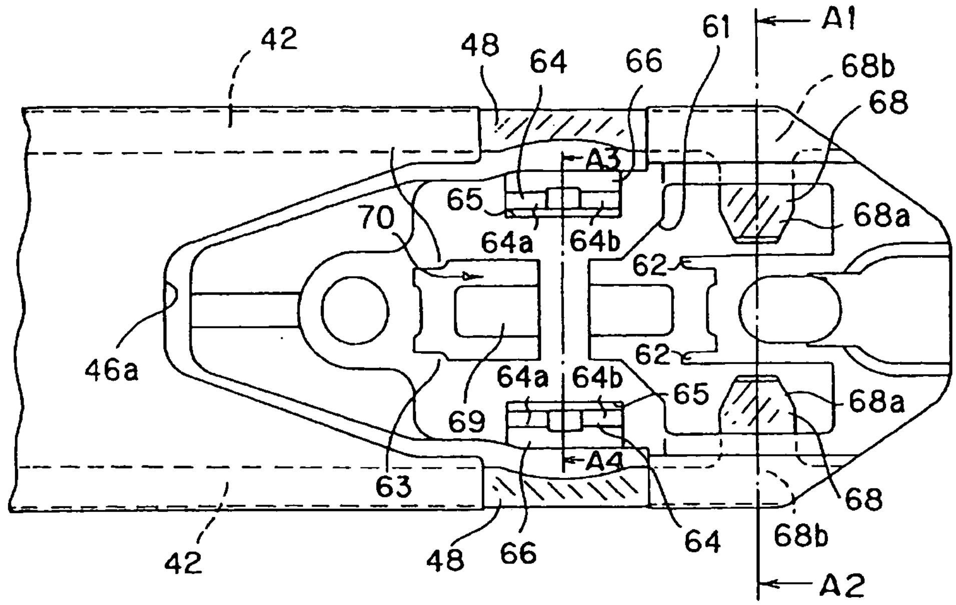

42
48
64
66
61
A1
68b
68
A3
65
70
64a
64b
68a
62
46a
62
64a
64b
65
68a
69
A4
63
68
42
48
66
64
68b
A2

FIG. 22

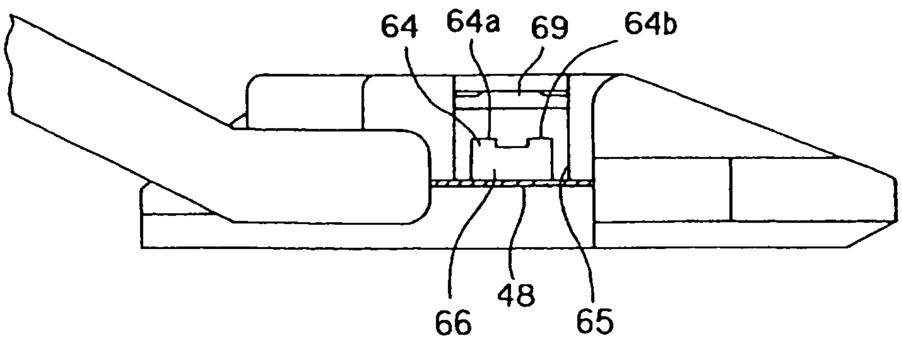

64
64a
69
64b
66
48
65

FIG. 23

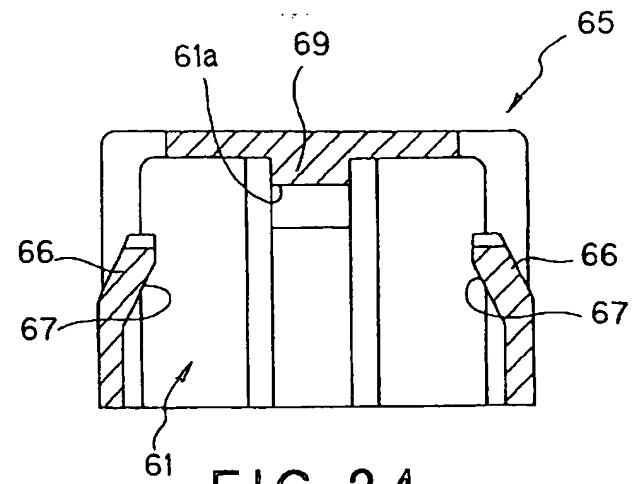


FIG. 24

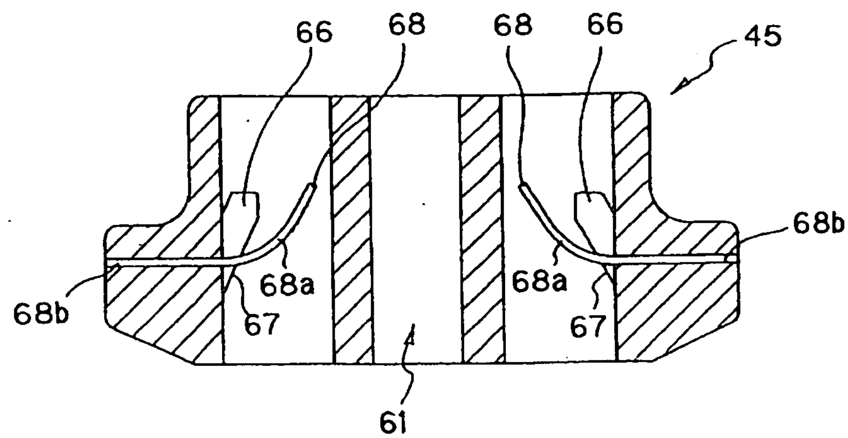


FIG. 25

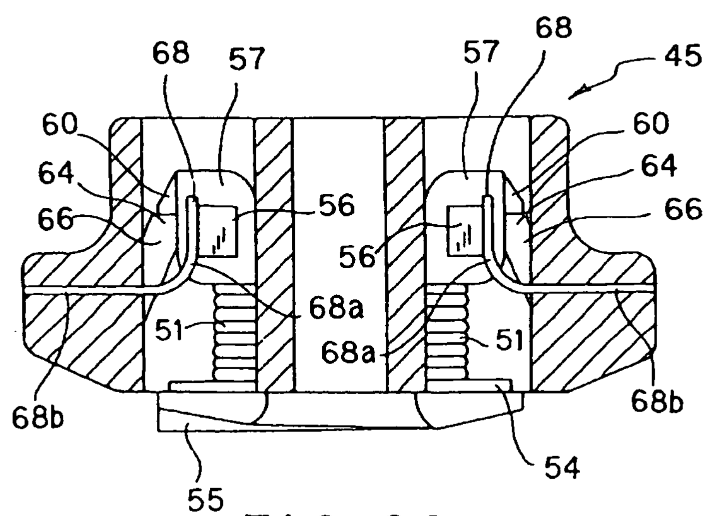


FIG. 26

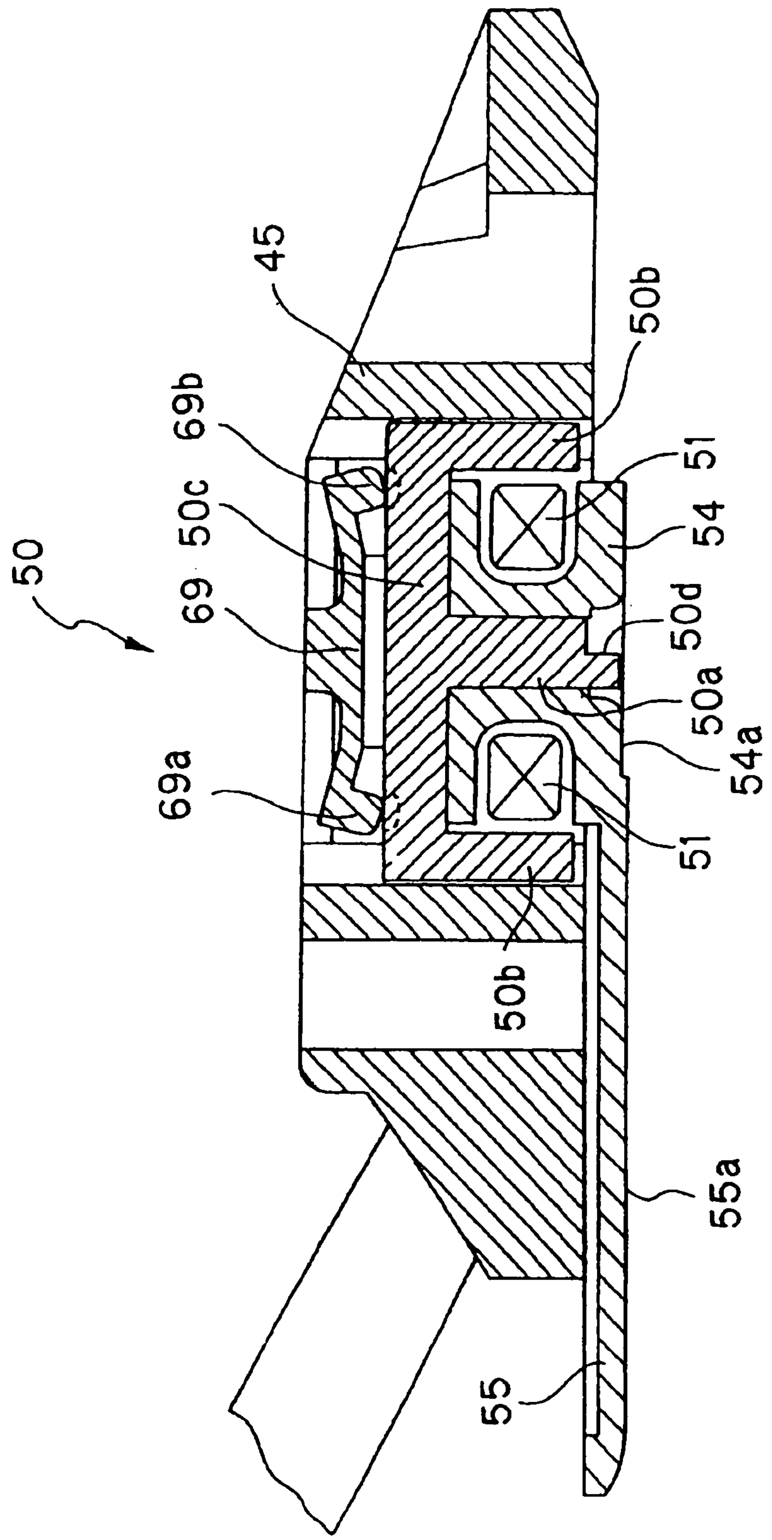


FIG. 27

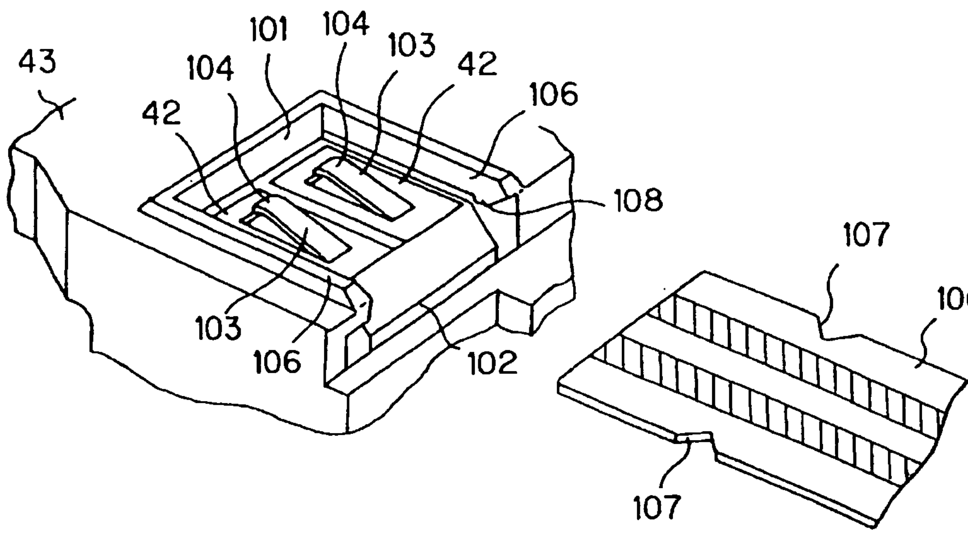

43
101
104
104
103
42
42
106
108
107
100
103
106
102
107

FIG. 28

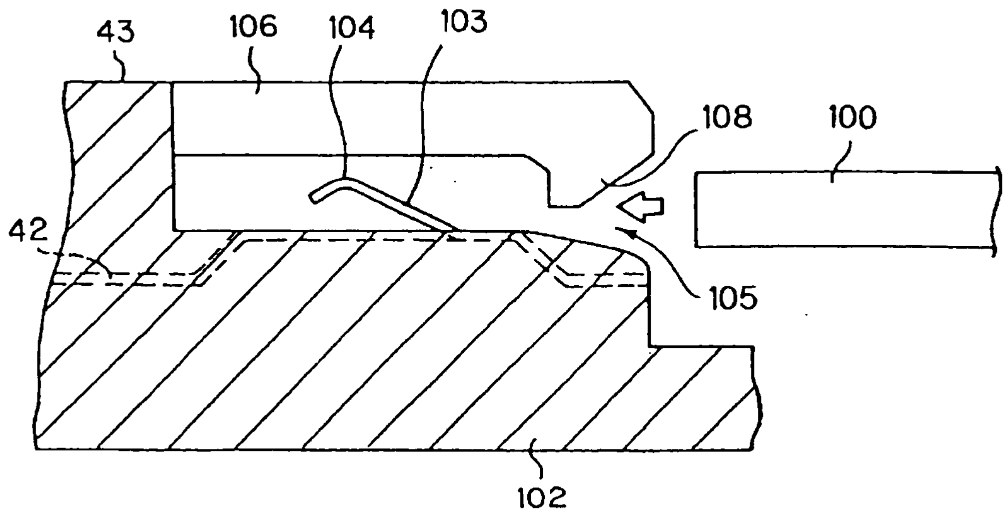

43
106
104
103
108
100
42
105
102

FIG. 29

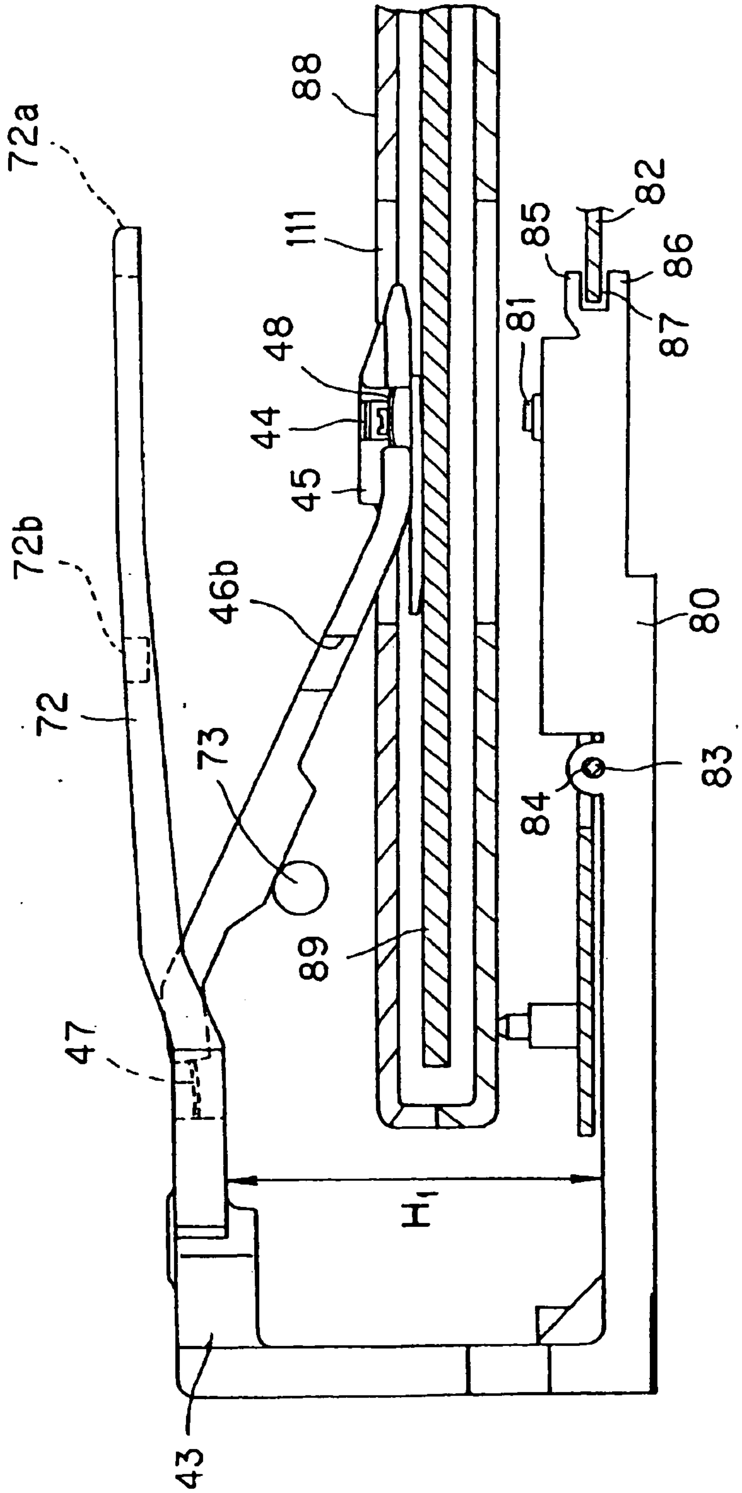


FIG. 30

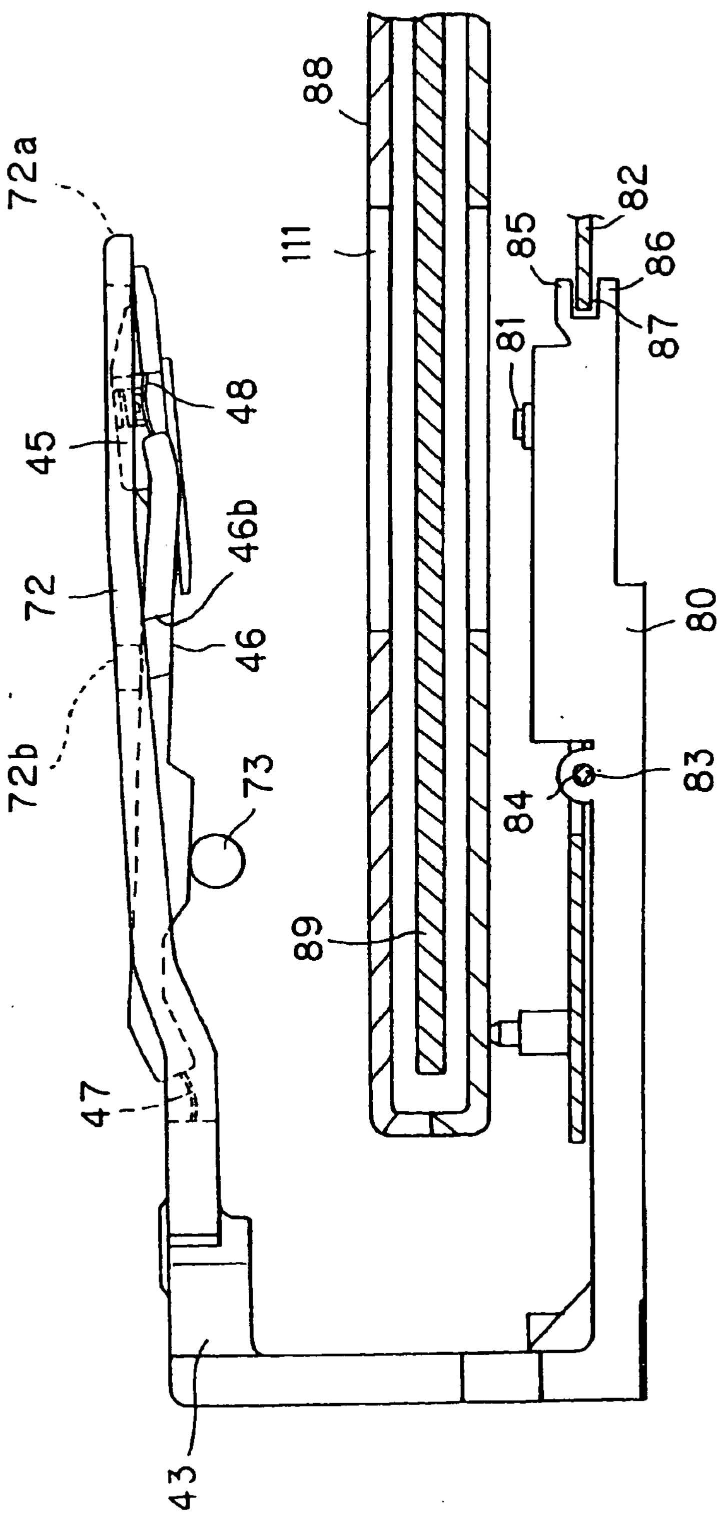


FIG. 31

MAGNETIC HEAD INCLUDING STEPPED CORE AND MAGNETO-OPTICAL RECORDING DEVICE USING THE SAME

TECHNICAL FIELD

This invention relates to a magnetic head, and a magnetic head and a magneto-optical disc recording device used for recording on a recording medium. Particularly, this invention relates to a magnetic head for supplying a magnetic field when recording an information signal onto a recording medium, and a magnetic head and a magneto-optical disc recording device used for recording on a recording medium.

BACKGROUND ART

There have been used magnetic recording media such as a magnetic disk and a magnetic tape on which an information signal is magnetically recorded and reproduced, and magneto-optical recording media such as a magneto-optical disc on which an information signal is recorded and reproduced by using the magneto-optical effect of a recording film.

On a magnetic recording medium such as a magnetic disk or a magnetic tape, an external magnetic field is applied to change the local direction of magnetization of the magnetic recording medium by using a magnetic head, thus writing an information signal.

On the other hand, on a magneto-optical recording medium such as a magneto-optical disc, while a condensed laser beam is cast onto a recording film, an external vertical magnetic field modulated in accordance with an information signal is applied by using a magnetic head to a portion which is locally heated to the Curie temperature or higher, thus writing the information signal. That is, in the portion heated to the Curie temperature or higher of the recording film of the recording medium, the coercive force is lost and the direction of magnetization is changed in accordance with the external magnetic field. On the magneto-optical recording medium, a laser beam which is weaker than in recording is cast onto the recording film and the rotation of the plane of polarization of the laser beam corresponding to the direction of magnetization due to a Kerr effect is detected, thus reading out the information signal.

An example of the magnetic head used for the magneto-optical recording medium will now be described with reference to FIG. 1. A magnetic head **200** shown in FIG. **1** has a magnetic core member **202** on which a coil **201** for magnetic modulation is wound. The magnetic core member **202** is made of a material having a high magnetic permeability and has a substantially prism-shaped base **203**, substantially prism-shaped yokes **204*a*, 204*b*** provided to protrude upward from both ends of the base **203**, and a substantially prism-shaped magnetic core **205** provided to stand upward from the base **203** at a position between the yokes **204*a*, 204*b***, as shown in FIG. 2. On outer circumferential surface of the magnetic core **205** of the magnetic core member **202**, the coil **201** is wound as shown in FIG. **1**.

When a current corresponding to an information signal is supplied to the coil **201**, the magnetic head **200** generates a magnetically modulated vertical magnetic field from a distal end portion **205*a*** of the magnetic core **205** on which the coil **201**. is wound. In the magnetic head **200**, the distal end portion **205*a*** of the magnetic core **205** is cause to closely contact or slide in contact with the magneto-optical recording medium, and the vertical magnetic field generated from the distal end portion **205*a*** of the magnetic core **205** is applied to the recording film of the magneto-optical recording medium, thus writing the information signal to the magneto-optical recording medium.

For a magneto-optical recording medium, a recording/reproducing device for the purpose of recording and reproducing music data is practically used. With such a recording/reproducing device for carrying out recording and reproduction on a magneto-optical disc, though a sufficient transfer rate is achieved in the case of recording and reproducing ordinary music data, a higher transfer rate is desired in the case of recording and reproducing image data in a computer or the like. As for music data, too, a higher transfer rate is desired in the case where duplication or shift is carried out.

To realize such a higher transfer rate, power saving and improvement in the magnetic field inversion band are made in the recording/reproducing device. Specifically, the inductance of the magnetic head **200** is reduced and miniaturization of the magnetic head **200** is done. Particularly, since the magnetic field is narrowed down and concentrated at the distal end portion **205*a*** of the magnetic core **205**, improvement in the generation efficiency of the magnetic field due to a so-called edge effect can be realized by narrowing the distal end portion **205*a***.

In the magnetic head **200** shown in FIG. **1**, narrowing the distal end portion **205*a*** of the magnetic core **205** causes reduction in the cross-sectional area of the distal end portion **205*a***. Therefore, the range where an effective magnetic field is obtained is narrowed and it is difficult to carry out appropriate write operation onto the magneto-optical recording medium. That is, if the area of the distal end portion **205*a*** of the magnetic core **205** is reduced, the intensity of an effective magnetic field applied to a predetermined recording track on the magneto-optical recording medium is insufficient for a positional deviation that is generated when an actuator for driving an objective lens within the recording/reproducing device into a focusing direction and a tracking direction makes a fine adjustment of the position of the objective lens, a positional deviation that is generated when the magneto-optical recording medium is loaded on the recording/reproducing device, and a positional deviation that is generated by the fluctuation of the magnetic head in the direction of height due to the wavering of the magneto-optical recording medium. Therefore, it is very difficult to carry out stable write operation of the information signal onto the magneto-optical recording medium.

If the distal end portion **205*a*** of the magnetic core **205** is narrowed, the heat generated in the magnetic core member **202** concentrates at the magnetic core **205** and the magnetic core **205** is deteriorated by a high temperature. Therefore, a sufficient magnetic field cannot be generated.

Generally, in the magnetic head **200**, when a current corresponding to an information signal is supplied to the coil **201**, a magnetic field modulated by the information signal to be recorded is generated from the distal end portion **205*a*** of the magnetic core **205** on which the coil **201** is wound. In this case, electric losses proportionate to the number of inversions of the magnetic field are generated. The electric losses mainly include a hysteresis loss due to the delay in the change of the direction of magnetization within the magnetic core member **202** from the change of the magnetic field by the coil **201**, and an eddy-current loss due to the flow of an eddy current induced by the inversion of the magnetic field within the magnetic core member **202**. All these losses are consumed as heat.

In the case where recording of music data is to be carried out as in the conventional technique, the calorific value due

to the above-described electric losses is relatively small because of a low data transfer rate. Moreover, since the distal end portion. **205***a* of the magnetic core **205** has a large cross-sectional area and can efficiently release the generated heat toward the base **203** and the yokes **204***a*, **204***b* of the magnetic core member **202**, the influence of such heating is not problematical.

However, in the case where the data transfer rate is high, the number of inversions of the external vertical magnetic field applied to the magneto-optical recording medium increases and therefore the calorific value due to the above-described electric losses increases, too. If the distal end portion **205***a* of the magnetic core **205** is narrowed, the generated heat cannot be efficiently released toward the base **203** and the yokes **204***a*, **204***b* of the magnetic core member **202** and the generated heat concentrates at the magnetic core **205**, thus causing an abrupt increase in the temperature of the magnetic core **205**. Moreover, in the magnetic head **200**, it is often the case that a substantially cylindrical bobbin having the coil **201** wound on its outer circumferential surface is inserted in the magnetic core **205**. If such a bobbin made of a synthetic resin or the like having a poor thermal conductivity is mounted on the outer circumferential surface of the magnetic core **205**, the radiation property of the magnetic core **205** is deteriorated.

As a result, the temperature of the magnetic core **205** rises close to the Curie point and the magnetic core **205** becomes magnetically unstable. Therefore, appropriate write operation to the magneto-optical recording medium cannot be carried out. If the temperature rises to a point where the inductance is reduced, the current flowing through the coil **201** increases to generate thermal runaway, which may damage the magnetic head **200** or may damage a magnetic head unit or a recording/reproducing device using this magnetic head **200**.

DISCLOSURE OF THE INVENTION

Thus, it is an object of the present invention to a magnetic head for supplying a magnetic field when recording an information signal onto a recording medium, and a magnetic head and a magneto-optical disc recording device used for recording on a recording medium, which enable solution of the above-described problem of the conventional magnetic head, restraint of magnetic deterioration due to heating, and realization of a higher transfer rate.

A magnetic head according to the present invention comprises: a substantially prism-shaped magnetic core portion having a distal end portion cut out to form a step, the magnetic core portion being form so that the cross-sectional area of the distal end portion is smaller than the cross-sectional area of a proximal end portion; and a coil wound on the outer circumferential surface of the magnetic core portion. The length of one side of the distal end portion is not less than 0.3 mm and not more than 0.45 mm, and the length of the other side orthogonal to the one side is not less than 0.4 mm and not more than 0.55 mm.

The height of the step formed at the distal end portion of the magnetic core portion is set to be not less than 0.3 mm and not more than a half of the length of the magnetic core portion.

Another magnetic head according to the present invention comprises: a core formed substantially in an E-shape by a substantially prism-shaped magnetic core portion having a distal end portion cut out to form a step, the magnetic core portion being form so that the cross-sectional area of the distal end portion is smaller than the cross-sectional area of a proximal end portion, and a pair of yokes arranged on both sides of the magnetic core portion; and a coil wound on the outer circumferential surface of the magnetic core portion and supplied with a current based on an information signal to be recorded onto a recording medium. The length of one side of the distal end portion of the magnetic core portion that is substantially parallel to the direction of movement of the recording medium is not less than 0.3 mm and not more than 0.45 mm, and the length of one side substantially orthogonal to the direction of movement of the recording medium is not less than 0.4 mm and not more than 0.55 mm.

A magneto-optical disc recording device according to the present invention comprises: an optical pickup unit arranged on the side of one surface of a magneto-optical disc and adapted for casing a condensed light beam to the magneto-optical disc; and a magnetic head arranged on the side of the other surface of the magneto-optical disc to face the optical pickup unit and adapted for applying an external magnetic field based on an information signal to be recorded onto the magneto-optical disc. The magnetic head used in this device has a core formed substantially in an E-shape by a substantially prism-shaped magnetic core portion having a distal end portion cut out to form a step, the magnetic core portion being formed so that the cross-sectional area of the distal end portion is smaller than the cross-sectional area of a proximal end portion, and a pair of yokes arranged on both sides of the magnetic core portion, and the magnetic head also has a coil wound on the outer circumferential surface of the magnetic core portion. The length of one side of the distal end portion substantially orthogonal. to a recording track on the magneto-optical disc is not less than 0.3 mm and not more than 0.45 mm, and the length of one side substantially parallel to the recording track of the magneto-optical disc is not less than 0.4 mm and not more than 0.55 mm.

The other objects and specific advantages of the present invention will be further clarified by the following description of embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view showing an example of a conventional magnetic head.

FIG. **2** is a perspective view showing the structure of a magnetic core member of the conventional magnetic head.

FIG. **3** is a perspective view showing a disc cartridge used in a magneto-optical recording/reproducing device to which the present invention is applied.

FIG. **4** is a perspective view showing the disc cartridge, as viewed from the bottom.

FIG. **5** is a schematic cross-sectional view showing a state such that the disc cartridge is loaded on a chassis within the magneto-optical recording/reproducing device to which the present invention is applied.

FIG. **6** is a perspective view showing the relation between a magnetic head unit and an optical pickup of the magneto-optical recording/reproducing device.

FIG. **7** is a schematic perspective view showing the relation between the disc cartridge, the magnetic head unit, and the optical pickup.

FIG. **8** is a perspective view showing an example of a magnetic head to which the present invention is applied.

FIGS. **9** and **10** are schematic views showing the positional relation between a magnetic head unit having the magnetic head according to the present invention and a magneto-optical disc before and after the following by the magnetic head unit.

FIG. 11 is an enlarged view showing essential portions of a distal end portion of the magnetic head according to the present invention, as viewed from the x-direction.

FIG. 12 is a perspective view showing another example of the magnetic head according to the present invention.

FIG. 13 is a perspective view showing still another example of the magnetic head according to the present invention.

FIG. 14 is a perspective view showing still another example of the magnetic head according to the present invention.

FIG. 15 is a perspective view showing still another example of the magnetic head according to the present invention.

FIG. 16 is a plan view showing an example of a magnetic head unit having the magnetic head according to the present invention.

FIG. 17 is a side view thereof.

FIG. 18 is an exploded side cross-sectional view showing a magnetic head portion constituting the magnetic head unit.

FIG. 19 is a side view showing a bobbin and a coil.

FIG. 20 is a plan view thereof.

FIG. 21 is a front view thereof.

FIG. 22 is a plan view showing a head attaching portion.

FIG. 23 is a side view thereof.

FIG. 24 is a cross-sectional view along a line A3–A4 in FIG. 22.

FIG. 25 is a cross-sectional view along a line A1–A2 in FIG. 22.

FIG. 26 is a cross-sectional view along a line A5–A6 in FIG. 16.

FIG. 27 is a cross-sectional view along a line A7–A8 in FIG. 16.

FIG. 28 is a perspective view showing an external circuit connecting portion provided on a fixed portion.

FIG. 29 is a cross-sectional view thereof.

FIG. 30 is a side view showing a state such that the magnetic head portion of the magnetic head unit slides in contact with the magneto-optical disc.

FIG. 31 is a side view showing a state such that the magnetic head portion of the magnetic head unit is moved away from the magneto-optical disc.

BEST MODE FOR CARRYING OUT THE INVENTION

A magnetic head according to the present invention and a magneto-optical recording/reproducing device using this magnetic head will now be described in detail with reference to the drawings.

First, an example will be described in which the present invention is applied to a magnetic head for applying an external magnetic field modulated in accordance with an information signal to a magneto-optical disc at the time of recording.

Prior to the description of the present invention, a disc cartridge is described in which a magneto-optical disc used as a recording medium for a magneto-optical recording/reproducing device using the magnetic head according to the present invention is housed.

This disc cartridge has a cartridge body 4 formed by abutting a pair of upper half 2 and lower half 3 to each other and connecting their circumferential edges by a plurality of screws or an adhesive, and a magneto-optical disc 5 rotatably housed inside the cartridge body 4, as shown in FIGS. 3 and 4.

The magneto-optical disc 5 is formed by applying a recording film (hereinafter referred to as a signal recording layer) made of a magnetic material onto a disc substrate made of a transparent synthetic resin material such as polycarbonate and having a diameter of approximately 64 mm. A center hole is provided substantially at a central part of the disc substrate of this magneto-optical disc 5, and a chucking plate 6 for the purpose of chucking with a magnet provided on a disc table, which will be described later, is attached to the center hole. The chucking plate 6 is made of a ferromagnetic material such as a metal having a substantially circular flat plate-like shape, and is joined and attached to the disc substrate by caulking a part of the disc substrate with heat or ultrasonic waves or by using an adhesive. A hole 6*a* is provided substantially at a central part of the chucking plate 6.

The pair of upper half 2 and lower half 3 constituting the cartridge body 4 is formed in a substantially rectangular flat plate-like shape with a synthetic resin, and the length of one side thereof is substantially equal to the diameter of the magneto-optical disc 5 housed therein. Substantially at a central part of the lower half 3, a chucking aperture 7 for exposing outward the chucking plate 6 attached to the magneto-optical disc 5 is provided. The chucking aperture 7 has a substantially circular shape and is formed with a size such that a disc table attached to a spindle motor of the magneto-optical recording/reproducing device, which will be described later, can enter the chucking aperture 7.

On the cartridge body 4, there are provided a substantially rectangular head aperture 8 formed on the side of the upper half 2 with a size such that a magnetic head unit of the magneto-optical recording/reproducing device, which will be described later, can operate between the inner and outer circles on the major surface of the magneto-optical disc 5, and a substantially rectangular pickup aperture 9 formed at a position facing the head aperture, on the side of the lower half 3, with a size such that an optical pickup unit of the magneto-optical recording/reproducing device, which will be described later, can scan between the inner and outer circles on the major surface of the magneto-optical disc 5.

The disc cartridge 1 has a shutter member 11 for preventing entry of dust and particles from the head aperture 8 and the pickup aperture 9. The shutter member 11 closes the head aperture 8 and the pickup aperture 9 and is attached to the cartridge body 4 so that it is slidable substantially in parallel with the direction of arrow A in FIGS. 3 and 4, which is the direction of insertion/ejection of the disc cartridge 1 to/from the recording device. When the disc cartridge 1 is not used, the shutter member 11 is locked by a lock member to a position for closing the head aperture 8 and the pickup aperture 9. When the disc cartridge 1 is inserted into the magneto-optical recording/reproducing device, the locking of the shutter member 11 by the lock member is canceled, interlocking with a shutter opening mechanism of the recording device, and the shutter member 11 is moved in the direction for opening the head aperture 8 and the pickup aperture 9.

On the lower half 3, there are provided substantially circular positioning holes 12*a*, 12*b* at the corner portions on one side on the forward stage and the rear stage in the direction of arrow A in FIGS. 3 and 4, which is the direction of insertion to/ejection from the magneto-optical recording/reproducing device, and engaged recess portions 13 formed

at the two corner portions on the forward stage by cutting out a part thereof. The positioning hole 12*b* on the rear stage has a larger diameter than the positioning hole 12*a* on the forward stage.

On the lower half 3, a plurality of identification holes 14 are provided at the corner portion on the other side on the rear stage in the direction of insertion to/ejection from the recording device, that is, the direction of arrow A in FIGS. 3 and 4. The plurality of identification holes 14 are for identifying the type of the magneto-optical disc 5 housed in the cartridge body 4, for example, for identifying whether writing an information signal onto the magneto-optical disc 5 is possible or not. A save notch 15 is provided at a lateral edge portion on the rear end side corresponding to the identification holes 14. By moving the save notch 15. into the cartridge body 4, the user can change the depth of a part of the plural identification holes 14 and can set whether writing an information signal onto the magneto-optical disc 5 is possible or not.

Moreover, on the lower half 3, a magneto-optical disc identification recess portion 16 is formed by cutting out a part near the positioning hole 12*a* on the forward stage with a predetermined depth. This magneto-optical disc identification recess portion 16 is to identify whether the housed disc is the magneto-optical disc 5 or not, on the basis of its depth.

When the disc cartridge 1 constituted as described above is inserted in the magneto-optical recording/reproducing device, as shown in FIG. 5, the disc cartridge 1 is position and thus loaded' by the engagement of positioning pins provided on a chassis. 17 with the positioning pins 12*a*, 12*b*. FIG. 5 is a schematic cross-sectional view showing the state in which the disc cartridge 1 is loaded on the chassis 17 in the magneto-optical recording/reproducing device.

When the disc cartridge 1 is inserted in the magneto-optical recording/reproducing device shown in FIG. 5, the disc cartridge 1 is held by a cartridge holder, not shown. In this case, the shutter member 11 of the disc cartridge 1 is opened by a shutter opening mechanism provided on the cartridge holder and therefore the head aperture 8 and the pickup aperture 9 of the disc cartridge 1 are opened. The disc cartridge 1, held by the cartridge holder, is lowered toward the chassis 17.

When the disc cartridge 1 is lowered toward the chassis 17, the chucking plate 6 of the magneto-optical disc 5 exposed outward from the chucking aperture 7 of the disc cartridge 1 is chucked to a disc table 18 rotatably provided substantially at a central portion on the chassis 17.

The disc table 18 is connected to rotate unitedly with the driving shaft of a spindle motor 19 attached to the chassis 17, and is rotationally driven by the spindle motor 19. At the center of rotation of the disc table 18, a positioning protrusion to be engaged with the center hole of the magneto-optical disc 5 is provided. The positioning protrusion is formed in a substantially conical pedestal-shape so that the center hole of the magneto-optical disc 5 is smoothly engaged with the positioning protrusion. A magnet is provided on the positioning protrusion on the disc table 18. When the center hole of the magneto-optical disc 5 is engaged with the positioning protrusion the magnet magnetically attracts the chucking plate 6 and holds the magneto-optical disc 5 on the disc plate 18. Thus, the magneto-optical disc 5 housed in the disc cartridge body 4 is positioned on the disc table 18 on the chassis 17.

On the chassis 17, positioning pins 20*a*, 20*b* to be engaged with the positioning holes 12*a*, 12*b* are provided at the positions corresponding positioning holes 12*a*, 12*b* of the disc cartridge 1. When the disc cartridge 1 is loaded on the chassis 17, the positioning holes 12*a*, 12*b* are engaged with the positioning pins 20*a*, 20*b*, and the disc cartridge 1 is thus positioned to the chassis 17.

In the magneto-optical recording/reproducing device according to the present invention, an optical pickup unit 22 is arranged to face one side of the magneto-optical disc 5, as shown in FIGS. 5 to 7. The optical pickup unit 22 has an optical block section. In the optical block section, a light source made of a laser diode or the like, various optical devices for leading a laser beam emitted from the light source to an objective lens 23, and a photodetector for detecting a return light from the magneto-optical disc are provided. The optical pickup unit 22 has an actuator for moving the objective lens 23 in a focusing direction and in a tracking direction. The optical pickup unit 22 is supported by a supporting member 25 attached to the chassis 17 via a pair of guide shafts 26 so that the optical pickup unit 22 can move between the inner and outer circles on the magneto-optical disc 5. The optical pickup unit 22 is moved between the inner and outer circles on the magneto-optical disc 5 by a pickup feed motor, not shown, provided on the chassis 17.

In the magneto-optical recording/reproducing device, a magnetic head unit 27 is provided on the side of the other surface of the magneto-optical disc 5. The magnetic head unit 27 is attached to a distal end portion of a supporting arm 28 fixed to the optical pickup unit 22 via a gimbal spring 28*a*. The magnetic head unit 27 slides in contact with the major surface of the magneto-optical disc 5 and is supported to be movably between the inner and outer circles. The magnetic head unit 27 is provided at the distal end portion of the elastic gimbal spring 28*a* bent at a predetermined angle and is thus enabled to follow the wavering of the magneto-optical disc 5 in the direction of height.

On the magnetic head unit 27, a magnetic head 29 is attached to face the objective lens 23 of the optical pickup unit 22 situated on the side of one surface of the magneto-optical disc 5.

The magnetic head 29 is for applying an external magnetic field based on an information signal to the signal recording layer of the magneto-optical disc 5, and has a magnetic core member.30 and a coil 31 for magnetic modulation wound on the magnetic core member 30, as shown in FIG. 8. The magnetic core member 30 is made of a material having a high magnetic permeability and has a substantially prism-shaped base 32, substantially prism-shaped yokes 33*a*, 33*b* provided to stand upward from both ends of the base 32, and a substantially prism-shaped magnetic core 34 provided to stand upward from the base 32 at a position between the yokes 33*a*, 33*b*.

Of these parts, the magnetic core 34 is formed to be longer than the yokes 33*a*, 33*b*, and has a step 35 formed thereon with a predetermined height by cutting out one side of its distal end surface 34*a* along a direction substantially perpendicular to the recording track on the magneto-optical disc 5. That is, the magnetic core 34 has the step 35 such that the cross-sectional area of a distal end portion is smaller than the cross-sectional area of a proximal end portion 36. The step 35 is formed to stand upward from the proximal end portion 36.

The coil 31 is wound on the outer circumferential surface of the magnetic core 34, over the entire circumference except for the step 35.

In the following description, the feed direction and the moving direction of the magnetic head unit 27, that is, the

direction substantially perpendicular to the recording track on the magneto-optical disc 5, is referred to as an x-direction, and the direction substantially parallel to the recording track is referred to as a y-direction. The direction of height of the magnetic core is referred to as a z-direction.

The magnetic core member 30 has the following dimensions. For example, as shown in FIG. 8, the height "a" of the magnetic core 34 including the base 32 is 1.76 mm, and the height "b" of the yokes 33*a*, 33*b* including the base 32 is 1.45 mm. The length "c" of the magnetic core member 30 in the x-direction, that is, the length "c" of each of the base 32, the yokes 33*a*, 33*b* and the magnetic core 34 in the x-direction, is 0.5 mm, and the length "d" of the proximal end portion 36 of the magnetic core 34. in the y-direction is 0.7 mm. The length d' of the step 35 of the magnetic core 34 in the y-direction is 0.4 mm, and the height "e" of the step 35 of the magnetic core 34 is 0.4 mm.

When a current corresponding to an information signal is supplied to the coil 31, the magnetic head 29 according to the present invention generates a vertical magnetic field modulated on the basis of the information signal to be recorded, from the distal end surface 34*a* of the magnetic core 34 on which the coil 31 is wound. While causing the distal end surface 34*a* of the magnetic core 34 to closely contact or slide in contact with the signal recording surface of the magneto-optical disc, the magnetic head 29 applies the vertical magnetic field generated from the distal end surface 34*a* of the magnetic core 34 to the signal recording layer of the magneto-optical disc 5.

The magneto-optical recording/reproducing device according to the present invention has such a structure that the magnetic head unit 27 slides in contact with the side facing the other surface of the magneto-optical disc 5, as will be described later, and a constant distance is maintained between the distal end surface 34*a* of the magnetic head 29 and the magneto-optical disc 5.

Since the magnetic core 34 constituting the magnetic head 29 has the step 35 at the distal end portion which is narrower than the proximal end portion 36, the magnetic field to be applied to the signal recording layer of the magneto-optical disc 5 can be concentrated and narrowed down to the distal end surface 34*a* of the magnetic core 34 and improvement in the generation efficiency of the vertical magnetic field due to a so-called edge effect can be realized.

In the magneto-optical recording/reproducing device constituted as described above, at the time recording, the optical pickup unit 22 and the magnetic head unit 27 cooperate to write an information signal onto the magneto-optical disc 5.

Specifically, in the magneto-optical recording/reproducing device, the optical pickup unit 22 casts a laser beam condensed by the objective lens 23 onto the signal recording layer of the magneto-optical disc 5 and thus locally heats the signal recording layer to the Curie temperature or higher. The magnetic head unit 27 applies, by using the magnetic head 29, an external magnetic field modulated in accordance with an information signal to the part of the signal recording layer that is heated to the Curie temperature or higher, thus writing the information signal. At the part of the signal recording layer that is heated to the Curie temperature or higher, the coercive force is lost and the direction of magnetization is changed in accordance with the external magnetic field supplied from the magnetic head 29.

On the other hand, in the magneto-optical recording/reproducing device, at the time of reproduction, the optical pickup unit 22 casts a weaker laser beam than at the time of recording onto the signal recording layer of the magneto-optical disc 5 and detects the rotation of the plane of polarization of the laser beam corresponding to the direction of magnetization due to a Kerr effect, thus reading out the information signal.

Meanwhile, in the magneto-optical recording/reproducing device to which the present invention is applied, when the magneto-optical disc 5 housed in the cartridge body 4 is positioned on the disc table 18 on the chassis 17, a slight positioning error may occur in the engagement of the positioning protrusion of the disc table 18 with the center hole of the magneto-optical disc 5. This positioning error causes generation of a positional deviation x_1 of the magnetic head 29 in the x-direction with respect to the recording track. This positional deviation x_1 is approximately 0.1 mm at the maximum.

The optical pickup unit 22 used in the magneto-optical recording/reproducing device to which the present invention is applied, fine adjustment of the position of the objective lens 23 is made by the actuator 24. Specifically, the optical pickup unit 22 follows the positional variance of the recording track of the rotating magneto-optical disc 5 while having the objective lens 23 controlled by the actuator 24. Thus, the spot position of the laser beam is adjusted to be constantly on the recording track. The positional variance of the objective lens 23 by the actuator 24 causes generation of a positional deviation x_3 of the magnetic head 29 in the x-direction with respect to the recording track. In this case, the positional deviation x_3 is the variance range in the adjustment of the objective lens 23. The positional deviation x_3 is approximately 0.14 mm at the maximum.

Therefore, the positional deviation of the magnetic head 29 in the x-direction with respect to the recording track is approximately 0.32 mm, that is, $x_1+x_2+x_3=0.1+0.08+0.14$.

The magnetic head unit 27 follows the positional variance in the direction of the height with respect to the magneto-optical disc 5 while being supported by the gimbal spring 28*a* of the supporting arm 28. At the same time, the magnetic head unit 27 causes a positional deviation of the magnetic head 29 in the y-direction with respect to the recording track.

The positional relation between the magnetic head unit 27 and the magneto-optical disc 5 before and after the following by the magnetic head unit 27 is shown in FIG. 9.

As shown in FIG. 9, the magnetic head unit 27 is attached to the distal end portion of the supporting arm 28 via the gimbal spring 28*a*, and the gimbal spring 28*a* is inclined by a predetermined angle θ with respect to the horizontal direction of the supporting arm 28. When a positional variance Δz in the direction of height with respect to the magneto-optical disc 5 is generated, the magnetic head unit 27 is caused to keep the positional relation with the magneto-optical disc 5, with the gimbal spring 28*a* inclined by an angle $\Delta\theta$. Along with this, the magnetic head device 27 causes a positional deviation Δy of the magnetic head 29 in the y-direction with respect to the recording track.

The positional relation between the magnetic head unit 27 and the magneto-optical disc 5 before and after the following by the magnetic head unit 27 is schematically shown in FIG. 10. In FIG. 10, the length of the gimbal spring 28*a* is expressed by R, the position of the magnetic head unit 27 before the variance is expressed by (z_1, y_1), and the position after the variance is expressed by (z_2, y_2).

As seen from FIG. 10, the position of the magnetic head unit 27 before the variance can be expressed by $(z_1, y_1)=(R\sin\theta, R\cos\theta)$, and the position after the variance can be expressed by $(z_2, y_2)=(R\sin\theta+\Delta z, R\cos\theta+\Delta y)$.

The relation of $R^2=(z_2^2, y_2^2)=(R\cos\theta+\Delta y)^2+(R\sin\theta+\Delta z)^2$ is set up.

The actual length of the gimbal spring **28a** is approximately 20 mm and the angle 0 of the gimbal spring is approximately 15°. The positional variance Δz of the magnetic head unit **27** in the direction of height with respect to the magneto-optical disc **5** is approximately 0.8 mm. By entering these values into the above relational expression, the positional deviation Δy in the y-direction can be found. As a result of calculation, Δy=−0.23 mm is obtained. Therefore, the positional deviation of the magnetic head **29** in the y-direction with respect to the recording track is approximately 0.23 mm.

In the magneto-optical recording/reproducing device, a positional deviation of the magnetic head **29** in the y-direction with respect to the recording track might be generated by a temperature change because of the difference in the coefficient of thermal expansion between the material of the casing of the optical pickup unit **22** on which the supporting arm **28** is fixed and the material of the supporting arm **28**. If the temperature change is approximately 45° C. at the maximum, the positional deviation in the y-direction is approximately 0.03 mm at the maximum.

Therefore, the positional deviation of the magnetic head **29** in the y-direction with respect to the recording track is approximately 0.23+0.03=0.26 mm.

Meanwhile, in the magneto-optical recording/reproducing device which aims at recording/reproduction of music data as in the conventional technique, since the data transfer rate and the magnetic field inversion band may be low, a magnetic field can be generated with relatively low power even when the magnetic head **200** is used in which the distal end portion **205a** of the magnetic core **205** has a large area as shown in FIG. 1 and which has large inductance.

In the case where high speed data recording of computer data or image data is carried out, unlike the case of music data, a high magnetic field inversion range is required. Therefore, a magnetic head with high efficiency and low dissipation power is desired. In view of the dissipation power, a magnetic head with small inductance, that is, a magnetic head in which the distal end surface of a magnetic core in close contact with or abutted against a recording medium has a small area, is effective. By reducing the area of the distal end surface of the magnetic core, a magnetic field concentrates at the edge portion of the distal end surface and improvement in the generation efficiency of the magnetic field due to a so-called edge effect can be realized.

If the distal end portion **205a** of the magnetic core **205** is narrowed as in the conventional technique, the cross-sectional area of the distal end portion **205a** is reduced and the range where an effective magnetic field can be obtained is reduced, too. Therefore, it is very difficult to carry out appropriate write operation to the magneto-optical recording medium. The minimum value of the area of the distal end surface is obtained by adding the positional deviations in the x-direction and the y-direction. when attaching the magnetic head unit **27** to the optical pickup unit **29** via the supporting arm **28** and their changes with the lapse of time, to values in consideration of the positional deviation of approximately 0.26 mm of the magnetic head **29** in the x-direction with respect to the recording track and the positional deviation of approximately 0.32 mm of the magnetic head **29** in the y-direction with respect to the recording track, which are calculated before.

Specifically, the range where a sufficient magnetic field for stable recording operation can be provided in the magnetic head **29** is substantially equal to the range of the distal end surface **34a** of the magnetic core **34** which closely contacts or slides in contact with the magneto-optical disc **5**. By setting the area of the distal end surface **34a** of the magnetic core **34** to be substantially equal to the range of the above-described positional deviations in the x-direction and y-direction with respect to the magneto-optical disc **5**, the influence of such positional deviations can be avoided. If such positional deviations and their changes with the lapse of time are restrained to 0.05 mm or less, the length "c" of the step **35** of the magnetic core **34** in the x-direction is approximately 0.3 mm and the length d' in the y-direction is approximately 0.4 mm.

It is not easy to restrain such positional deviations and their changes with the lapse of time. If the conventional structure with restrained cost is used as the basis, the positional deviations and their changes with the lapse of time need to be approximately 0.2 mm. In such a case, the length "c" of the step **35** of the magnetic core **34** in the x-direction is approximately 0.45 mm and the length d' in the y-direction is approximately 0.55 mm.

In view of the above, in the magnetic head **29** according to the present invention, power saving and reduction in cost can be realized by setting the length "c" of the step **35** of the magnetic core **34** in the x-direction to be not less than 0.3 mm and not more than 0.45 mm, and setting the length d' in the y-direction to be not less than 0.4 mm and not more than 0.55 mm. Thus, a magnetic head for high-speed recording to cope with a higher transfer rate can be realized.

In the conventional magnetic head **200**, if the distal end portion **205a** of the magnetic core **205** is narrowed, the heat generated in the magnetic head member **204** concentrates at the magnetic core **205** and deterioration due to the high temperature occurs, making it difficult to generate a sufficient magnetic field.

On the contrary, in the magnetic head **29** according to the present invention, the distal end portion is cut -out to form the step **35** and the cross-sectional area of the distal end portion is made smaller than the cross-sectional area on the side of the proximal end portion **36**, as shown in FIG. **8**. In the magnetic head **29** formed in this manner, the heat generated in the magnetic core **34** can be efficiently released from the distal end portion side toward the proximal end portion **36**. Thus, the magnetic field generation efficiency of the magnetic core **34** can be improved and the heat generated in the magnetic core **34** can be efficiently released toward the base **32** and the yokes **33a**, **33b** of the magnetic core member **30**.

If the height "e" of the step **35** formed at the distal end portion of the magnetic core **34** is too low, it adversely affects the distribution of magnetic field. If the height "e" is too high, it adversely affects the radiation effect. Thus, the influence of the height "e" of the step **35** on the distribution of magnetic field is measured. The result of the measurement is shown in FIG. **11**. FIG. **11** is an enlarged view showing essential portions of the distal end portion of the magnetic head **29**, as viewed from the x-direction. FIG. **11** shows the contour line of the magnitude of a magnetic field generated when the same current is caused to flow in recording, with the height "c" of the step **35** varied. The magnitude of the magnetic field expressed by the contour line is a limit value of an effective external magnetic field in recording. In FIG. **11**, S indicates an average gap between the magneto-optical disc **5** and the magnetic head **29**, which is approximately 0.1 mm.

As shown in FIG. **11**, the contour line for e>1.0 shows that the step **35** has a sufficient height and that the distribution of

magnetic field is large on both edge of the distal end surface 34a because of an edge effect. The contour line is substantially symmetrical with respect to the centerline of the magnetic core 34 and shows similar distribution of magnetic field in the x-direction.

The contour line for e=0.4 and the contour line for e=0.3 show that though the width of an external magnetic field is smaller than in the case of e>1.0 because of the intake of the magnetic field by edges f1, f2 of the proximal end portion 36, a practically sufficient width is still obtained.

On the other hand, the contour line for e=0.2 and the contour line for e=0.1 show that the magnetic field taken in by edges f3, f4 of the proximal end portion 36 is too large and that the effective external magnetic field from the distal end surface 34a in recording is insufficient. In such cases, it is difficult to apply an appropriate external magnetic field to the signal recording layer of the magneto-optical disc 5.

Thus, it is clear that the height "e" of the step 35 must be at least 0.3 mm or larger. If the radiation effect of the magnetic core 34 is considered, it is experimentally clear that the height "e" of the step 35 may be half the length f of the magnetic core 34 or less.

Therefore, in the magnetic head 29, by setting the height "e" of the step 35 of the magnetic core 34 to be not less than 0.3 mm and not more than a half of the length f of the magnetic core 34, the heat generated in the magnetic core can be efficiently released toward the base 32 and the yokes 33a, 33b of the magnetic core member 30 while the magnetic field generation efficiency of the magnetic core 34 is improved.

It is desired that the cut-out width "g" in cutting out the distal end surface 34a of the magnetic core 34 is not more than 0.2 mm.

In the magnetic head 29 according to the present invention, the step 35 as shown in FIG. 8 is formed by cutting out one side of the distal end surface 34a of the magnetic core 34 over the x-direction. However, the present invention is not necessarily limited to such a structure.

For example, a step 37 as shown in FIG. 12 may be formed on the magnetic core 34 by cutting out both sides of the distal end surface in the x-direction. Similarly, a step 38 as shown in FIG. 13 may be formed in the magnetic core 34 by cutting out one side of the distal end surface 34a in the y-direction, or a step 39 as shown in FIG. 14 may be formed in the magnetic core 34 by cutting out both sides of the distal end surface 34a in the y-direction. Alternatively, a step 40 as shown in FIG. 15 may be formed by cutting out the distal end surface 34a in the x-direction and the y-direction. In FIGS. 12 to 15, the portions equivalent to those of the magnetic core member 30 shown in FIG. 8 are denoted by the same numerals and will not be described further in detail.

An example of a magnetic head unit on which a magnetic head according to the present invention is loaded will now be described.

This magnetic head unit 41 has a pair of long elastic conductive members 42 arranged substantially in parallel with each other, as shown in FIGS. 16 and 17. These conductive members 42 are formed by punching out a conductive thin metal plate of phosphor bronze, BeCu or the like. It is particularly desired that the conductive members 42 are made of an age-hardening material such as BeCu, the hardening degree of which changes depending upon the time of heat treatment. By using the age-hardening material to form the conductive members 42, desired elastic forces of the conductive members 42 can be obtained easily.

At the distal end portions of the conductive members 42, feeding terminals are provided which are electrically connected with a coil of a magnetic head 44 attached to a head attaching portion 45, as will be described later. At the proximal end portions thereof, terminal portions are provided which constitute an external circuit connecting portion connected with a flexible wiring board for feeding the coil of the magnetic head 44, as will be described later.

On the side of the proximal ends of the pair of conductive members 42, a fixed portion 43 for attaching the magnetic head unit 41 to an attachment base to be arranged inside the magneto-optical recording/reproducing device is integrally provided by molding a synthetic resin material. On the side of the distal ends of the pair of conductive members 42, a head attaching portion 45 to which the magnetic head 44 made of a magnetic core member, a coil and the like is attached to constitute a magnetic head portion 49 is integrally provided by molding a synthetic resin material. Between the proximal end portions of the pair of conductive members 42 where the fixed portion 43 is provided and the distal end portions of the conductive members 42 where the head attaching portion 45 is provided, a head support 46 is integrally provided by molding a synthetic resin material.

This magnetic head unit 41 has the conductive members 42 connected to the coil of the magnetic head 44, and also has the fixed portion 43, the head attaching portion 45 and the head support 46 as the supporting member integrally formed with the conductive members 42. The proximal end side of the supporting member, that is, the fixed portion 43, is fixed on the attachment base to be arranged inside the magneto-optical recording/reproducing device, and the magnetic head 44 constituted similarly to the above-described magnetic head 29 is arranged on the distal end side of the supporting member, that is, on the head attaching portion 45.

The head support 46 is integrally provided at a halfway part of the pair of conductive members 42 so as to expose a part of the pair of conductive members 42 outward between the fixed portion 43 and the head support 46 and to expose a part of the pair of conductive members 42 outward between the head attaching portion 45 and the head support 46. The parts of the pair of conductive members 42 exposed outward between the fixed portion 43 and the head support 46 are first elastic displacement portions 47 as the center of fluctuation in the case where the head attaching portion 45 and the head support 46 fluctuate in the directions toward and away from the magneto-optical disc. The parts of the pair of conductive members 42 exposed outward between the head attaching portion 45 and the head support 46 are second elastic displacement portions 48 which are displaced in the opposite direction of the direction of the displacement of the first elastic displacement portions 47 so as to maintain predetermined attitudes of the head attaching portion 45, the magnetic head 44 attached thereto, and a sliding contact portion 55, which will be described later, when the head attaching portion 45 and the head support 46 are moved and displaced in the directions toward and away from the magneto-optical disc.

In the magnetic head unit 41, a fluctuation quantity regulating arm 72 for regulating the quantity of fluctuation when the head attaching portion 45 and the head support 46 fluctuate in the direction away from the magneto-optical disc is formed to protrude from the fixed portion 43 toward the head support 46 and the head attaching portion 45. In the magnetic head unit 41, the fluctuation quantity regulating arm 72 regulates the quantity of fluctuation of the head attaching portion 45 and the head support 46, and determines the height position when the head attaching portion 45 is pushed up.

In the magnetic head unit **41**, the head attaching portion **45**, the head support **46**, the fixed portion **43** and the fluctuation quantity regulating arm **72** are arranged so that these members do not overlap each other when projected on a plan view, as shown in FIG. **16**. By arranging the respective members in this manner, it is possible to mold the magnetic head unit **41** in a single molding operation with a pair of upper and lower metal molds.

The respective parts constituting the magnetic head unit **41** will now be described in detail.

First, the head attaching portion **45** integrally provided on the distal end side of the pair of conductive members **42**, and the magnetic head **44** attached to the head attaching portion **45** will be described.

The magnetic head **44** having a magnetic core member and a coil is attached to the head attaching portion **45**, thus constituting the magnetic head portion **49**. In recording an information signal onto a magneto-optical disc, the magnetic head unit **41** slides in contact with one major surface of the rotated magneto-optical disc and maintains the magnetic core member constituting the magnetic head **44** at a constant distance from the signal recording layer of the magneto-optical disc.

The magnetic head **44** attached to the head attaching portion **45** to constitute the magnetic head portion **49** is the above-described magnetic head to which the present invention is applied. The magnetic head **44** is constituted by a magnetic core member **50** made of a magnetic material such as ferrite and a bobbin **52** on which a coil **51** is wound, as shown in FIG. **18**. The magnetic core member **50** has a magnetic core **50*a***, a pair of yokes **50*b*** provided on both sides of the magnetic core **50*a***, and a base **50*c*** connecting the proximal ends of the magnetic core **50*a*** and the pair of yokes **50*b***, and is formed substantially in an E-shape as a whole.

The magnetic core **50*a*** of the magnetic core member **50** is formed to be longer than the yokes **50*b***, and a step **50*d*** having a predetermined height is formed by cutting out a part of the distal end surface of the magnetic core **50*a***. That is, the magnetic core **50*a*** has the step **50*d*** such that the cross-sectional area of the distal end portion is smaller than the cross-sectional area of the proximal end portion, and this step **50*d*** is formed to stand upward from the proximal end portion.

The bobbin **52** constituting the magnetic head **44** together with the magnetic core member **50** is formed by molding a synthetic resin material such as liquid crystal polymer, polyphenylene sulfide or the like, which can be molded with extremely high accuracy. The bobbin **52** has at its central part a magnetic core insertion hole **53** in which the magnetic core **50*a*** of the magnetic core member **50** is inserted, and a coil winding portion formed in a recessed shape is provided to surround the magnetic core insertion hole **53**, as shown in FIGS. **18, 19, 20** and **21**. On one end side of the bobbin **52**, a flange portion **54** protruding in a direction orthogonal to the axial direction of the magnetic core insertion hole **53** is integrally formed. A lower surface **54*a*** of the flange portion **54** is a surface facing the major surface of the magneto-optical disc.

A sliding contact portion **55** which slides in contact with the major surface of the magneto-optical disc is provided to protrude from one end of the flange portion **54** toward the fixed portion **43** of the supporting member. A sliding contact surface **55*a*** of the sliding contact portion **55** is formed to protrude a little more than the surface **54*a*** of the flange portion **54** facing the major surface of the magneto-optical disc, and thus slides in contact with the major surface of the magneto-optical disc, as shown in FIG. **20**. That is, the bobbin **52** has a step between the surface **54*a*** facing the major surface of the magneto-optical disc near the magnetic core insertion hole **53** and the surface facing the major surface of the magneto-optical disc on the sliding contact surface **55*a*** of the sliding contact portion **55**. When the sliding contact portion **55** slides in contact with the magneto-optical disc, a predetermined gap is formed between the portion near the magnetic core insertion hole **53** and the magneto-optical disc.

A side of the sliding contact portion **55** that is situated on the outer circumference of the magneto-optical disc when the magnetic head portion **49** is caused to slide in contact with the magneto-optical disc is an inclined portion **55*b*** along the outer circumference of the magneto-optical disc, as shown in FIG. **20**. Thus, when the magnetic head portion **49** slides and moves in contact with the rotated magneto-optical disc, the sliding contact surface **55*a*** of the sliding contact portion **55** smoothly slide in contact with the entire surface of the magneto-optical disc including the portion near the outer circumference.

On the other end side of the bobbin **52**, a pair of terminal supporting portions. **57** for supporting a pair of coil connection terminals **56** made of a conductive material such as phosphor bronze or the like are provided to protrude. These terminal supporting portions **57** are provided to protrude in parallel, facing each other in the direction orthogonal to the axial direction of the magnetic core insertion hole **53**. The end portions on one side of the terminal supporting portions **57** are caused to protrude and the pair of coil connection terminals **56** are integrally mounted so that the coil connection terminals **56** are buried in the terminal supporting portions **57**. That is, the coil connection terminals **56** are mounted on the terminal supporting portions **57** by so-called insertion molding.

Connection terminals **58** of the coil **51** wound on the bobbin **52** are wound on the coil connection terminals **56** several times and are electrically connected with the coil connection terminals **56**. To realize secure electrical connection of the connection terminals **58** of the coil **51** with the coil connection terminals **56**, the connection terminals **58** are connected with the coil connection terminals **56** by using a conductive adhesive or solder.

Two recessed portions **59** formed in the bobbin **52** by providing the pair of terminal supporting portions **57** to protrude to face each other are fitting portions of the magnetic core member **50**.

On one side of the upper ends of the terminal supporting portions **57**, engagement pawl portions **60** are provided which engaging portions to be relatively engaged with engagement step portions as engaged portions provided in an attachment hole provided in the head attaching portion **45** when the bobbin **52** is fitted in the attachment hole. The engagement pawl portions **60** are extended in the axial direction of the magnetic core insertion hole **53** provided in the bobbin **52**, and engagement pawls **60*a*** are provided to protrude on one side of their distal ends.

The head attaching portion **45**, to which the magnetic core member **50** and the bobbin **52** constituting the magnetic head **44** are attached, is formed by molding a non-conductive synthetic resin material and the magnetic head **44** is attached to its central part, as shown in FIGS. **18, 22, 23, 24** and **25**.

An attachment hole **61** is formed in the head attaching portion **45** so that the magnetic core member **50** and the

bobbin **52** are fitted in the attachment hole **61**. This attachment hole **61** is formed in the shape of a bottomed recess in which a side facing the magneto-optical disc is an aperture. On the sides facing each other in the longitudinal direction of the attachment hole **61**, first holding pieces **62** and second holding pieces **63** for pinching and holding the yokes **50b** provided on both sides of the magnetic core member **50** inserted into the attachment hole **61** are provided to protrude. These first holding pieces **62** and second holding pieces **63** are provided to protrude from the surfaces facing each other in the longitudinal direction of the attachment hole **61** so that the holding pieces face each other. The spacing between the first holding pieces **62** and the spacing between the second holding pieces **63** are slightly smaller than the thickness of the magnetic core member **50**, and the first holding pieces **62** and the second holding pieces **63** pinch and hold, by compression bonding, the yokes **50b** of the magnetic core member **50** inserted in the attachment hole **61**.

On both lateral sides of the attachment hole **61**, engagement step portions **64** are provided which are engaged portions to be relatively engaged with the engagement pawls **60a** of the engagement pawl portions **60** provided on the bobbin **52** inserted in the attachment hole **61**. The engagement step portions **64** are formed at distal end surfaces of elastic displacement pieces **66** formed by providing substantially U-shaped cut-in grooves **65** on the surfaces facing each other in the longitudinal direction of the attachment hole **61**, from the side to be the bottom side of the attachment hole **61**, that is, from the upper side of the head attaching portion **45**. That is, the engagement step portions **64** are formed by the cut-in grooves **65** provided on the surfaces facing each other in the longitudinal direction of the attachment hole **61**, and are constituted by parts of the elastic displacement pieces **66**.

On the upper surface of each engagement step portion **64** constituted by a part of the elastic displacement piece **66**, that is, on the surface relatively engaged with the engagement pawl **60a** formed on the bobbin **52**, a protruding portion **64a** is formed at one end and a similar protruding portion **64b** is formed at the other end. The upper surfaces of the protruding portions **64a, 64b** are flat surfaces, and the engagement pawl **60a** to be engaged with the engagement step portion **64** is abutted against the engagement step portion **64** on the upper surfaces of the protruding portions **64a, 64b**.

By thus providing the two protruding portions **64a, 64b** on the upper surface of the engagement step portion **64**, the bobbin **52** can be easily made parallel to the head attaching portion **45** with high accuracy.

To form the engagement step portions **64**, the upper ends of the elastic displacement pieces **66** on which the engagement step portions **64** are formed by providing the cut-in grooves **65** are inclined to protrude inside the attachment hole **61**. The inclined surfaces facing each other of the elastic displacement pieces **66** are insertion guide portions **67** which are abutted against parts of the outer circumferential portion of the bobbin **52** inserted in the attachment hole **61** so as to guide the direction of insertion and the position of insertion of the bobbin **52**.

In the attachment hole **61**, as shown in FIG. **25**, feeding terminals **68** formed by bending the distal ends of the pair of conductive members **42** are provided to protrude. The feeding terminals **68** are for feeding the coil **51** wound on the bobbin **52** inserted in the attachment hole **61**, and electrically contact the coil connection terminals **56** on which the connection terminals **58** of the coil **51** are wound. The feeding terminals **68** are provided at positions which enable contact with the coil connection terminals **56** on which the connection terminals **58** of the coil **51** wound on the bobbin **52** are wound when the bobbin **52** is attached in the attachment hole **61**. As shown in FIG. **22**, the feeding terminals **68** are provided to protrude on the lateral surfaces facing each other of the attachment hole **61**, on the side where the first holding pieces **62** are provided.

Each of the feeding terminals **68** formed by bending the distal ends of the pair of conductive members **42** has a bent portion **68a** which protrudes within the attachment hole **61** and elastically contacts the coil connection terminal **56**, and a portion **68b** where the head attaching portion **45** made of a synthetic resin is molded, as shown in FIG. **25**. The bent portion **68a** is formed by bending the feeding terminal **68** from one end of the head attaching portion **45** along the direction of inserting the bobbin **52** into the attachment hole **61**, and by a stress caused by this bending, the feeding terminal **68** elastically contacts the coil connection terminal **56**.

Of the feeding terminals **68**, at least parts of the bent portions **68a** which contact the coil connection terminals **56** are processed by one of gold plating, nickel plating and solder plating, in order to reduce the electric resistance at the time of contact. It is desired that a material used for plating has smaller electric resistance than the feeding terminals **68** in order to reduce the electric resistance at the time of contact. Similarly, it is desired that at least parts of the coil connection terminals **56** which contact the bent portions **68a** are processed by one of gold plating, nickel plating and solder plating, in order to reduce the electric resistance at the time of contact.

On a bottom surface **61a** of the attachment hole **61**, that is, on the inner surface on the top side of the head attaching portion **45**, a pressing member **69** for pressing the magnetic core member **50** toward the magneto-optical disc is formed by expansion, as shown in FIGS. **18, 22, 23** and **24**. This pressing member **69** has elasticity and is abutted against the base **50c** of the magnetic core member **50** constituting the magnetic head **44** attached in the attachment hole **61**, thus pressing the magnetic core member **50** toward the magneto-optical disc. Specifically, both end portions **69a, 69b** of pressing member **69** are abutted against the base **50c** of the magnetic core member **50** and press the magnetic core member **50** toward the magneto-optical disc, as shown in FIG. **27**.

As described above, in the magnetic head unit **41**, the magnetic head **44** is fixed by engaging the engagement pawl portions **60** formed on the bobbin **52** with the engagement step portions **64** formed on the head attaching portion **45** and pressing the magnetic core member **50** toward the magneto-optical disc by the pressing member **69** formed on the head attaching portion **45**.

A gap **60** is formed around the pressing member **69**, as shown in FIG. **22**, and the magnetic core member **50** pressed by the pressing member **69** is exposed outward from the gap **60**. Therefore, the state of the magnetic core member **50** can be visually recognized from outside and a defective magnetic head in which breakage of the magnetic core member **50** or the like has occurred can be immediately detected.

A process of assembling the magnetic head unit **49** constituted as described above will now be described and the assembled magnetic head unit **49** will be described subsequently.

To assemble the magnetic head unit **49**, the magnetic core member **50** is attached into the attachment hole **61** of the

head attaching portion **45**. The magnetic core member **50** is inserted into the attachment hole **61** from an opening end **61** opening on the side of the head attaching portion **45** facing the magneto-optical disc, with a portion of the magnetic core member **50** on the side of the connection part **50c** used as an insertion end, as shown in FIG. **18**. As both lateral portions on the side of the yoke **50b** are fitted between the first holding pieces **62** and the second holding pieces **63**, the magnetic core member **50** inserted in the attachment hole **61** is pinched and held by the first holding pieces **62** and the second holding pieces **63** and thus temporarily fixed in the attachment hole **61**. In this case, the upper surface of the magnetic core member **50** is abutted against the pressing member **69**.

Then, the bobbin **52** having the coil **51** wound thereon is inserted into the attachment hole **61** in which the magnetic core member **50** is arranged. The bobbin **52** is inserted into the attachment hole **61** from the opening end **61** so that the side where the engagement pawl portions **60**, **60** are provided to protrude is caused to correspond to the surface of the attachment hole **61** where the engagement step portions **64** are provided and so that the coil connection terminals **56** are caused to correspond to the feeding terminals **68** provided to protrude within the attachment hole **61**. In this case, the magnetic core **50a** of the magnetic core member **50** is inserted into the magnetic core insertion hole **53** of the bobbin **52**. As the bobbin **52** is inserted further into the attachment hole **61**, the bobbin **52** is inserted toward the inner side of the attachment hole **61** while the outer lateral surface of the side on which the coil connection terminals **56** are attached is caused to slide in contact with the insertion guide portions **67** formed on the surfaces facing each other of the elastic displacement pieces **66** protruding within the attachment hole **61**. In this case, since the bobbin **52** is inserted into the attachment hole **61** with the outer lateral side guided by the insertion guide portions **67**, the direction of insertion into the attachment hole **61** is regulated. Therefore, the bobbin **52** is inserted into the attachment hole **61** in such a state that the magnetic core **50a** of the magnetic core member **50** temporarily fixed and arranged in the attachment hole **61** is accurately inserted in the magnetic core insertion hole **53**.

When the bobbin **52** is being inserted into the attachment hole **61**, the elastic displacement pieces **66** are elastically displaced outward from the attachment hole **61** by the engagement pawl portions **60**. As the bobbin **52** is further inserted, the engagement pawls **60a** at the distal ends of the engagement pawl portions **60** reach the engagement step portions **64** formed at the distal ends of the elastic displacement pieces **66** and the elastic displacement pieces **66** are elastically restored, thus realizing relative engagement of the engagement pawl portions **60** with the engagement step portions **64**, as shown in FIG. **26**. In this case, the bobbin **52** is pressed toward the magneto-optical disc by the pressing member **69** via the magnetic core member **50**, as shown in FIG. **27**. Thus, the bobbin **52** is attached and fixed in the attachment hole **61** so that the flange portion **54** is exposed to the side of the head attaching portion **45** facing the magneto-optical disc.

Moreover,.when the bobbin **52** is attached in the attachment hole **61**, the coil connection terminals **56** are pressured in contact with the feeding terminals **68** protruding within the attachment hole **61**, as shown in FIG. **26**, thus realizing electric connection of the coil **51** with the conductive member 42. The feeding terminals **68** have the elastic bent portions **68a** and pressured contact is made in such a state that the bent portions **68** provide elastic forces to the coil terminal connection **56**, thus realizing secure electric contact.

The magnetic head unit **49**, assembled as described above, can be assembled simply by sequentially inserting the magnetic core member **50** and the bobbin **52** having the coil **51** wound thereon into the attachment hole **61**, and there is no need to use an adhesive for fixing the magnetic core member **50** and the coil **51** to the head attaching portion **45**. Therefore, the assembly is very easy. Since the position of attachment of the magnetic head **44** to the head attaching portion **45** can be determined by the position of relative engagement of the engagement pawls **60a** with the engagement step portions **64**, the positioning of the attachment position can be carried out accurately and easily. In this magnetic head portion **49**, there is no need to use solder or the like for the connection between the coil connection terminals **56** provided on the bobbin **52** and the feeding terminals **68**. Therefore, the work for assembling the magnetic head portion **49** is extremely simple.

Meanwhile, in the magnetic head portion **49**, the bobbin **52** has the step between the surface facing the major surface of the magneto-optical disc near the magnetic core insertion hole **53** and the surface facing the major surface of the magneto-optical disc in the sliding contact portion **55**. When the sliding contact portion **55** slides in contact with the magneto-optical disc, a predetermined gap is formed between the portion near the magnetic core insertion hole **53** and the magneto-optical disc

Therefore, when the magnetic head portion is caused to slide in contact with the magneto-optical disc, the gap between the magnetic core **50a** of the magnetic core member **50** inserted in the magnetic core insertion hole **53** and the magneto-optical disc is determined in accordance with the step, the height of the bobbin **52** in the axial direction of the magnetic core insertion hole **53** and the length of the magnetic core **50a** extending from the base **50c** to the step **50d**. Therefore, by forming the bobbin **52** and the magnetic core member **50** with high accuracy, it is possible to accurately maintain the gap between the magnetic core **50a** and the magneto-optical disc, that is, the flying height of the magnetic core member **50**, at a constant value.

Specifically, in this magnetic head unit **41**, the flying height of the magnetic core member **50** over the magneto-optical disc is regulated only by the shapes of the bobbin **52** and the magnetic core member **50**. Therefore, in the magnetic head unit **41**, only the bobbin **52** and the magnetic core member **50** require particularly high processing accuracy. The supporting member made up of the head attaching portion **45**, the head support **46** and the fixed portion **43** which are integrally molded with the conductive members **42** does not require high processing accuracy. That is, the metal mold used for molding the supporting member of the magnetic head unit **41** does not require high accuracy and the supporting member can be easily manufactured.

The head support **46** which supports the magnetic head unit **49**, constituted as described above, at the distal end via the second elastic displacement portions **48** will now be described.

The head support **46** is formed by molding a synthetic resin between the pair of conductive members **42**. Since the head support **46** is formed by molding a synthetic resin between the pair of conductive members **42**, the head support **46** fixes the positions of the pair of conductive member **42** and provides rigidity to these conductive members **42**. The head support **46** supports the head attaching portion **45** constituting the magnetic head portion **49** attached at the distal ends of the conductive members **42** so that the head attaching portion **45** can fluctuated and displaced from the second elastic displacement portions **48** as the center.

When the head support 46 is not operated to fluctuate, the head support 46 is obliquely arranged so that it gradually approaches the magneto-optical disc from the fixed portion 43 to the head attaching portion 45.

On the side of the head support 46 where the head attaching portion 45 is supported, a first cut-out portion 46*a* is formed, to which the portion on the sliding contact portion 55 of the magnetic head 44 attached to the head attaching portion 45 is exposed, as shown in FIG. 14. When the head attaching portion 45 is fluctuated and displaced from the second elastic displacement portions 48 as the center, the portion on the sliding contact portion 55 is caused to enter the first cut-out portion 46*a* of the head support 46.

On the lateral edge of the head support 46 adjacent to the fluctuation quantity regulating arm 72, a second cut-out portion 46*b* is formed so as to prevent a second regulating piece 72*b* of the fluctuation quantity regulating arm 72, which will be described later, and the head support 46 from overlapping each other when the magnetic head unit 41 is projected in a plan view.

The fixed portion 43 and the fluctuation quantity regulating arm 72, and the head attaching portion 45 and the head support 46, are simultaneously molded by insertion molding in which a synthetic resin is injected and molded in a cavity of the metal mold device having the pair of conductive members 42 arranged therein. By thus providing the second cut-out portion 46*b* of the head support 46 and preventing the second regulating piece 72*b* of the fluctuation quantity regulating arm 72 and the head support 46 from overlapping each other when the magnetic head unit 41 is projected in a plan view, it is possible to mold the magnetic head unit 41 in a pair of upper and lower metal molds and to improve the production efficiency of the magnetic head unit 41.

The fixed portion 43 provided on the proximal end side of the pair of conductive members 42 will now be described.

The fixed portion 43 is for fixing and supporting the magnetic head unit 41 on the attachment base which moves along the radial direction of the magneto-optical disc synchronously with the optical pickup unit arranged inside the magneto-optical recording/reproducing device. A fixed member insertion hole 74 in which a fixed member such as a fixed screw fixed to the attachment base is inserted is provided in the fixed portion 43. On the bottom side of the fixed portion 43, engagement recess portions are provided to protrude which are engaged with a pair of positioning pins provided to protrude on the attachment base.

On the fixed portion 43, an external circuit connecting portion 101 is provided to which a flexible printed wiring board and a flat connection cable 100 such as a flexible flat cable is connected for electrically connecting the magnetic head 44 attached to the head attaching portion 45 supported on the distal end side of the head support 46 with an external circuit, as shown in FIGS. 16, 28 and 29. The external circuit connecting portion 101 has a terminal portion supporting piece 102 provided to protrude on the proximal end side of the fixed portion 43, and terminal portions 103 formed on the proximal end side of the pair of conductive members 42 are extended on one major surface of the terminal portion supporting piece 102.

These terminal portions 103 are formed by providing substantially U-shaped tapered cut-in parts in the pair of conductive members 42 electrically connected with the coil 51 of the magnetic head 44 via the feeding terminals 68, and are elastically displaceable with their connecting portion sides to the conductive members 42 as the fulcrums. The terminal portions 103 are bent to protrude above the terminal portion supporting piece 102 and have bent portions 104 on their distal end sides. Therefore, as the bent portions 104 protruding above the terminal portion supporting piece 102 are pressed, the terminal portions 103 are elastically displaced toward the terminal portion supporting piece 102 with the connecting portion sides to the conductive members 42 as the fulcrums.

In the terminal portion supporting piece 102, cut-out holes are provided for entering the distal end sides of the terminal portions 103 when the terminal portions 103 are elastically displaced.

On both lateral sides facing each other of the terminal portion supporting piece 102, a pair of connection cable supporting pieces 106 are provided which form an insertion groove 105 for inserting the connection cable 100 electrically connected with the terminal portions 103 in cooperation with the terminal portion supporting piece 102. These connection cable supporting pieces 106 are formed to protrude above the terminal supporting piece 102 from the fixed portion 43 and form the insertion groove 105 together with the terminal portion supporting piece 102. On the lower sides facing the terminal portion supporting piece 102 of the connection cable supporting pieces 106, retaining pawls 108 are provided to protrude, which are engaged with cut-out grooves 107 formed by cutting out both sides of the connection cable 100 inserted in the insertion groove 105.

As the connection cable 100 is inserted into the insertion groove 105 from its distal end side, the connection table 100 is connected with the external circuit connecting portion 101 so that it is held between terminal portion supporting piece 102 and the connection cable supporting pieces 106. In this case, the connection cable 100 causes a connection pattern portion to be pressed in contact with the terminal portions 103 flexibly deformed to extend over the terminal portion supporting piece 102. As the connection pattern portion is pressed in contact with the terminal portions 103, the connection cable 100 is electrically connected with the pair of conductive members 42. The coil 51 of the magnetic head 44 is electrically connected with the external circuit via the connection cable 100 and the pair of conductive members 42, and enters the state in which the coil 51 is fed by the external circuit.

On the fixed portion 43, the fluctuation quantity regulating arm 72, which is formed to protrude from the proximal end side of the pair of conductive members 42 toward the distal end side of the conductive members 42 and adapted for regulating the quantity of fluctuation of the head attaching portion 45 and the head support 46, is integrally formed by using the same synthetic resin material as the fixed portion 43, as shown in FIGS. 16 and 17. Specifically, the fluctuation quantity regulating arm 72 is formed to extend along the head support 46 and the head attaching portion 45 from the fixed portion 43. At the distal end portion of the fluctuation quantity regulating arm 72, a first regulating portion 72*a* is formed which is abutted against the head attaching portion 45 to regulate the quantity of fluctuation of the head attaching portion 45 when the head attaching portion 45 and the head support 46 fluctuate. At the halfway portion of the fluctuation quantity regulating arm 72, a second regulating portion 72*b* is formed which is abutted against the head support 46 to regulate the quantity of fluctuation of the head support 46 when the head attaching portion 45 and the head support 46 fluctuate.

The first regulating piece 72*a* is formed to protrude from the distal end portion of the fluctuation quantity regulating arm 72 toward the head attaching portion 45. The first

regulating piece 72a is arranged at a position slightly away from the distal end of the head attaching portion 45, as projected in a plan view, when the head support 46 and the head attaching portion 45 do not fluctuate. When the head support 46 and the head attaching portion 45 are operated to fluctuate in the direction away from the loaded disc cartridge, the first regulating piece 72a is abutted against the distal end portion of the head attaching portion 45 and regulates the quantity of fluctuation of the head attaching portion 45.

The second regulating piece 72b is formed to protrude from the halfway portion of the fluctuation quantity regulating arm 72 toward the head support 46. The second regulating piece 72b is arranged at a position right above the second cut-out portion 46b formed in the head support 46, as projected in a plan view, when the head support 46 and the head attaching portion 45 are not operated to fluctuate. When the head support 46 and the head attaching portion 45 are operated to fluctuate in the direction away from the loaded disc cartridge, the second regulating piece 72b is abutted against a site adjacent to the second cut-out portion 46b of the head support 46 and regulates the quantity of fluctuation of the head support 46.

When a disc cartridge housing a magneto-optical disc is to be inserted in or ejected from the magneto-optical recording/reproducing device, the head attaching portion 45 and the head support 46 of the magnetic head unit 41 attached inside the magneto-optical recording/reproducing device are operated to fluctuate in the direction away from the position for setting the magneto-optical disc by a fluctuation operation member, which will be described later, in order to form a sufficient space from the optical pickup unit so as to carry out insertion or ejection of the disc cartridge. In this case, the first regulating piece 72a of the fluctuation quantity regulating arm 72 is abutted against the head attaching portion 45 and the second regulating piece 72b is abutted against the head support 46, thus regulating the quantities of fluctuation.

In this magnetic head unit 41, excessive fluctuation of the head attaching portion 45 and the head support 46 is regulated without putting excessive burden on the second elastic displacement portions 48, and therefore deformation and damage of the first elastic displacement portions 47 and the second elastic displacement portions 48 can be prevented. At the same time, the height position of the head attaching portion 45 after fluctuation can be regulated.

The magnetic head unit 41 constituted as described above is mounted on a moving base 80 movably attached within the magneto-optical recording/reproducing device, as shown in FIGS. 30 and 31. An optical pickup unit 81 is also mounted on the moving base 80. Therefore, in the magneto-optical recording/reproducing device, the magnetic head unit 41 moves synchronously with the optical pickup unit 81.

The moving base 80, on which the magnetic head unit 41 and the optical pickup unit 81 are mounted, is supported to be movable along the radial direction of a magneto-optical disc 89 housed in a disc cartridge 88 loaded in the magneto-optical recording/reproducing device, as a slide guide shaft 83 attached to a chassis substrate 82 on which a mechanical portion such as a disc rotation driving mechanism is mounted is caused to penetrate a through-hole 84 provided at a halfway part and then a slide guide portion 87 provided on one side of the chassis substrate 82 is supported by a pair of upper and lower engaging pieces 85, 86 provided to protrude on one end side. The moving base 80 is operated to move along the radial direction of the magneto-optical disc 89 via a pickup feed mechanism driven by a driving motor, not shown.

The optical pickup unit 81 is mounted on the distal end side of the moving base 80 so that an objective lens for condensing a light bean emitted from a light source onto the signal recording layer of the magneto-optical disc 89 faces the magneto-optical disc 89. In this case, the optical pickup unit 81 is mounted on the moving base 80 so that the optical axis of the objective lens is situated on the centerline of the magneto-optical disc 89.

On the other end side of the moving base 80, that is, the opposite side of the one end side where the optical pickup unit 81 is mounted, the magnetic head unit 41 is mounted. The fixed portion 43 of the magnetic head unit 41 is mounted on the moving base 80 so that the head support 46 extends on the disc cartridge 88 loaded on the cartridge loading portion. The magnetic head unit 41 is mounted on the moving base 80 by the fixed screw inserted in the fixed member insertion hole 74 and fitted in the moving base 80, as the engagement recess portions provided on the bottom side of the fixed portion 43 are engaged with the positioning pins provided to protrude on the distal end surface of the moving base 80 so as to determine the mounting position.

When the magnetic head unit 41 is mounted on the moving base 80, the magnetic core 50a of the magnetic core member 50 constituting the magnetic head 44 attached to the head attaching portion 45 supported at the distal end of the head support 46 via the second elastic displacement portions 48 is caused to face the objective lens of the optical pickup unit 81, with the magneto-optical disc 89 held between them. The purpose of this arrangement is to apply an external magnetic field to the light beam casting position on the magneto-optical disc 89.

As the moving base 80 is driven by the pickup feed mechanism, the magnetic head unit 41 mounted on the moving base 80 is sent in the radial direction of the magneto-optical disc 89, integrally with the optical pickup unit 81. The direction of the movement of the magnetic head unit 41 with respect to the magneto-optical disc 89 is a direction orthogonal to the longitudinal direction of the head support 46.

Meanwhile, the head support 46 extended on the disc cartridge 88 from the fixed portion 43 having a height H1 for holding the space for inserting and ejecting the disc cartridge 88, via the first elastic displacement portions 47, is obliquely formed so as to gradually approach the magneto-optical disc 89 loaded on the cartridge loading portion from the side of the fixed portion 43 toward the distal end portion side where the head attaching portion 45 is supported, as described above, in order to cause the head attaching portion 45 supported at the distal end of the head support 46 to slide in contact with the magneto-optical disc 89 loaded on the cartridge loading portion.

When the above-described fluctuation operation member 73 is not operated to fluctuate, the head support 46 causes the head attaching portion 45 supported on the distal end side to enter the disc cartridge 88 and causes the sliding contact portion 55 formed on the bobbin 52 to slide in contact with the magneto-optical disc 89, as shown in FIG. 28. When the sliding contact portion 55 is sliding in contact with the magneto-optical disc 89, as shown in FIG. 30, the first elastic displacement portions 47 are elastically displaced to provide an energizing force to energize the head support 46 toward the magneto-optical disc 89.

In the magneto-optical recording/reproducing device in which the magnetic head unit 41 is mounted, there is

provided a head fluctuation operation mechanism, not shown, which operates the fluctuation operation member 73 to fluctuate the head attaching portion 45 and the head support 46 from the first elastic displacement portions 47 as the center into the direction away from the disc cartridge 88. The head fluctuation operation mechanism operates the fluctuation operation member 73 to fluctuate the head attaching portion 45 and the head support 46 from the first elastic displacement portions 47 as the center into the direction away from the disc cartridge 88. In this case, the head attaching portion 45 of the magnetic head unit 41 is fluctuated to a position where it is abutted against the first regulating portion 72a of the fluctuation quantity regulating arm 72, and the head support 46 is fluctuated to a position where it is abutted against the second regulating portion 72b, as shown in FIG. 29. By thus fluctuating and displacing the head attaching portion 45 and the head support 46, the head attaching portion 45 is released from the disc cartridge 88 and a sufficient space from the optical pickup unit 81 for inserting or ejecting the disc cartridge 88 is formed, as shown in FIG. 31.

The magnetic head unit 41 mounted in the magneto-optical recording/reproducing device is moved in the radial direction of the magneto-optical disc 89, using the direction orthogonal to the extending direction of the head support 46 as the direction of movement. When the head attaching portion 45 is moved until the magnetic core 50a of the magnetic core member 50 is situated on the outermost circle side in the signal recording are of the magneto-optical disc 89, one side of the sliding contact portion 55 protrudes on the outer circumference of the magneto-optical disc 89. Thus, in order to prevent the one side of the sliding contact portion 55 from protruding from the magneto-optical disc 89 even when the head attaching portion 45 is moved to the outermost circle side of the magneto-optical disc 89, the inclined portion 55b inclined along the outer circumference of the magneto-optical disc 89 is formed on the one side of the sliding contact portion 55. Specifically, since the one side of the sliding contact portion 55 situated on the outer circumferential side of the magneto-optical disc is caused to be the inclined portion 55b, even when the head attaching portion 45 is moved to the thick outer circumferential side of the magneto-optical disc 89, the sliding contact portion 55 does not ride on the thick outer circumferential portion of the magneto-optical disc 89 and the sliding contact surface 55a of the sliding contact portion 55 securely slides in contact with the signal recording area of the magneto-optical disc 89 over the entire surface of the magneto-optical disc.

It is desired that the sliding contact portion 55 protruding toward the side of the fixed portion 43 of the supporting member is formed to have as large a quantity of protrusion as possible in order to reduce the equivalent mass. In recording, the magnetic head 49, having the sliding contact portion 55 attached thereto, passes through a window portion 111 of the disc cartridge 88 and slides in contact with the magneto-optical disc 89 housed in the disc cartridge 88. Therefore, the quantity of protrusion of the sliding contact portion 55 is regulated by the window portion 111 of the disc cartridge 88. However, it is desired to secure as large a quantity of protrusion as possible for the sliding contact portion 55.

By thus forming the sliding contact portion 55 to have as large quantity of protrusion as possible and thus reducing the equivalent mass, the defocusing quantity can be reduced.

Since the bobbin 52, having the sliding contact portion 55 formed thereon, relatively slides in contact with the rotating magneto-optical disc 89, it is desired that the bobbin 52 has excellent sliding property and wear resistance and a light weight and is made of a material which achieves high dimensional accuracy when molded. As the material constituting the bobbin 52, a synthetic resin material is used, such as polyphenylene sulfide (PPS), polyacetal (POM), polyarylate (PAR), polyimide 6, polyamide 66, polyethylene terephthalate (PET), polybutylene terephthalate (PBT), ultra-high molecular weight polyethylene (UHMW-PE), high molecular weight polyethylene (HMW-PE) or the like.

Since the fixed portion 43, the head support 46, the head attaching portion 45 and the fluctuation quantity regulating arm 72 do not contact the magneto-optical disc, these member do not need to use a material having excellent sliding property and wear resistance and can be formed by using an inexpensive resin material.

The fixed portion 43, the head attaching portion 45, the head support 46 and the fluctuation quantity regulating arm 73, made of a synthetic resin material, are simultaneously formed by insertion molding in which the synthetic resin material is injected and molded in the cavity of the metal mold having the pair of conductive members 42 arranged therein.

In this case, the magnetic head unit 41 can be formed by a single molding operation with a pair of upper and lower metal molds because the head attaching portion 45, the head support 46, the fixed portion 43 and the fluctuation quantity regulating arm 72 are arranged so as not to overlap each other, when projected in a plan view.

In the case where appropriate materials are selected for molding the fixed portion 43, the head attaching portion 45, the head support 46 and the fluctuation quantity regulating arm 72, respectively, a bicolor molding method may be used.

The feeding terminals 68 and the terminal portions 103 formed on the pair of conductive members 42 are processed by one of gold plate, nickel plating, and solder plating. By performing such plating processing, the contact resistance of the feeding terminals 68 and the terminal portions 103 are reduced and good electrical contact is realized.

Moreover, through-holes 109 for exposing parts of the conductive members 42 which are buried in the fixed portion 43 outward are provided on the upper side of the fixed portion 43, as shown in FIG. 16. Similarly, through-holes 110 for exposing parts of the conductive members 42 which are buried in the head support 46 outward are provided on the upper side of the head support 46. The parts of the conductive members 42 exposed through these through-holes 109, 110 are contact parts with respect to a checking equipment for checking the connection state of the conductive members 42 with the coil 51 of the magnetic head 44 and the electric property of the magnetic head 44.

The parts of the pair of conductive members 42 which are exposed outward and constitute the first elastic displacement portions 47 and the second elastic displacement portion 48 are also processed by one of gold plate, nickel plating, and solder plating. Thus, these parts are made anticorrosive.

In the above-described example, the present invention is applied to the magneto-optical disc recording/reproducing device for recording and reproducing an information signal. However, the present inventions may also be applied to a device having only the recording function.

In the above-described example, the present invention is applied to the magneto-optical disc recording/reproducing deice using a magneto-optical recording medium as a recording medium. However, the magnetic head according to the present invention is not limited to the above-described example and can also be applied to a magnetic recording medium such as a magnetic disk or a magnetic tape.

Industrial Applicability

As described above, the magnetic head according to the present invention can efficiently release the heat generated in the magnetic core toward the proximal end side while improving the magnetic field generation efficiency at the distal end portion of the magnetic core, and can also realize a magnetic head for high-speed recording which can achieve a higher transfer rate. If the magnetic head is applied to the magneto-optical disc recording device, a higher transfer rate of recording data is realized -and high-speed recording is made possible.

What is claimed is:

1. A magnetic head comprising:

a substantially prism-shaped magnetic core portion having a distal end portion cut out to form a step, the magnetic core portion being form so that the cross-sectional area of the distal end portion is smaller than the cross-sectional area of a proximal end portion; and

a coil wound on the outer circumferential surface of the magnetic core portion;

wherein the length of one side of the distal end portion is not less than 0.3 mm and not more than 0.45 mm, and the length of the other side orthogonal to the one side is not less than 0.4 mm and not more than 0.55 mm.

2. The magnetic head as claimed in claim 1, wherein the height of the step is not less than 0.3 mm and not more than a half of the length of the magnetic core portion.

3. A magnetic head comprising:

a core formed substantially in an E-shape by a substantially prism-shaped magnetic core portion having a distal end portion cut:out to form a step, the magnetic core portion being form so that the cross-sectional area of the distal end portion is smaller than the cross-sectional area of a proximal end portion, and a pair of yokes arranged on both sides of the magnetic core portion; and

a coil wound on the outer circumferential surface of the magnetic core portion and supplied with a current based on an information signal to be recorded onto a recording medium;

wherein the length of one side of the distal end portion of the magnetic core portion that is substantially parallel to the direction of movement of the recording medium is not less than 0.3 mm and not more than 0.45 mm, and the length of one side substantially orthogonal to the direction of movement of the recording medium is not less than 0.4 mm and not more than 0.55 mm.

4. The magnetic head as claimed in claim 3, wherein the height of the step is not less than 0.3 mm and not more than a half of the length of the magnetic core portion.

5. A magneto-optical disc recording device comprising:

an optical pickup unit arranged on the side of one surface of a magneto-optical disc and adapted for casing a condensed light beam to the magneto-optical disc; and

a magnetic head arranged on the side of the other surface of the magneto-optical disc to face the optical pickup, the magnetic head having a core formed substantially in an E-shape by a substantially prism-shaped magnetic core portion having a distal end portion cut out to form a step, the magnetic core portion being formed so that the cross-sectional area of the distal end portion is smaller than the cross-sectional area of a proximal end portion, and a pair of yokes arranged on both sides of the magnetic core portion, the magnetic head also having a coil wound on the outer circumferential surface of the magnetic core portion, wherein the length of one side of the distal end portion substantially orthogonal to a recording track on the magneto-optical disc is not less than 0.3 mm and not more than 0.45 mm, and the length of one side substantially parallel to the recording track of the magneto-optical disc is not less than 0.4 mm and not more than 0.55 mm.

6. The magneto-optical disc recording device as claimed in claim 5, wherein the height of the step of the magnetic head is not less than 0.3 mm and not more than a half of the length of the magnetic core portion.

* * * * *